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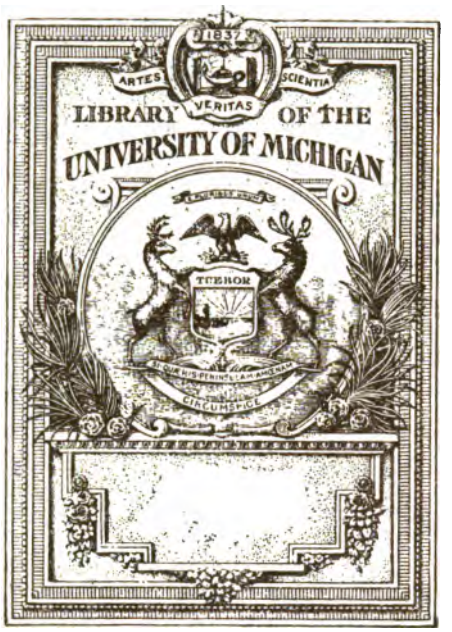
TWO RELATED INDUSTRIES



THE GIFT OF
F.C. Huyck & Sons

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TWO RELATED INDUSTRIES

FRANCIS CONKLING HUYCK
Founder of the Kenwood Mills

TWO
Related Industries

AN ACCOUNT OF

PAPER-MAKING AND OF PAPER-MAKERS' FELTS
AS MANUFACTURED AT THE KENWOOD MILLS
RENSSELAER, NEW YORK, U.S.A.
AND ARNPRIOR
ONTARIO, CANADA
THE TWO PLANTS OF

F. C. Huyck & Sons, Albany
New York

PREPARED BY
DIRECTION OF PERRY WALTON
TO MARK THE FIFTIETH YEAR SINCE THE FOUNDER
FRANCIS CONKLING HUYCK, ENTERED THE BUSINESS
AND THE TWENTY-FIFTH YEAR SINCE THE PLANT
AT RENSSELAER, NEW YORK, OPPOSITE ALBANY
WAS BUILT
1919

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BY
F. C. HUYCK & SONS

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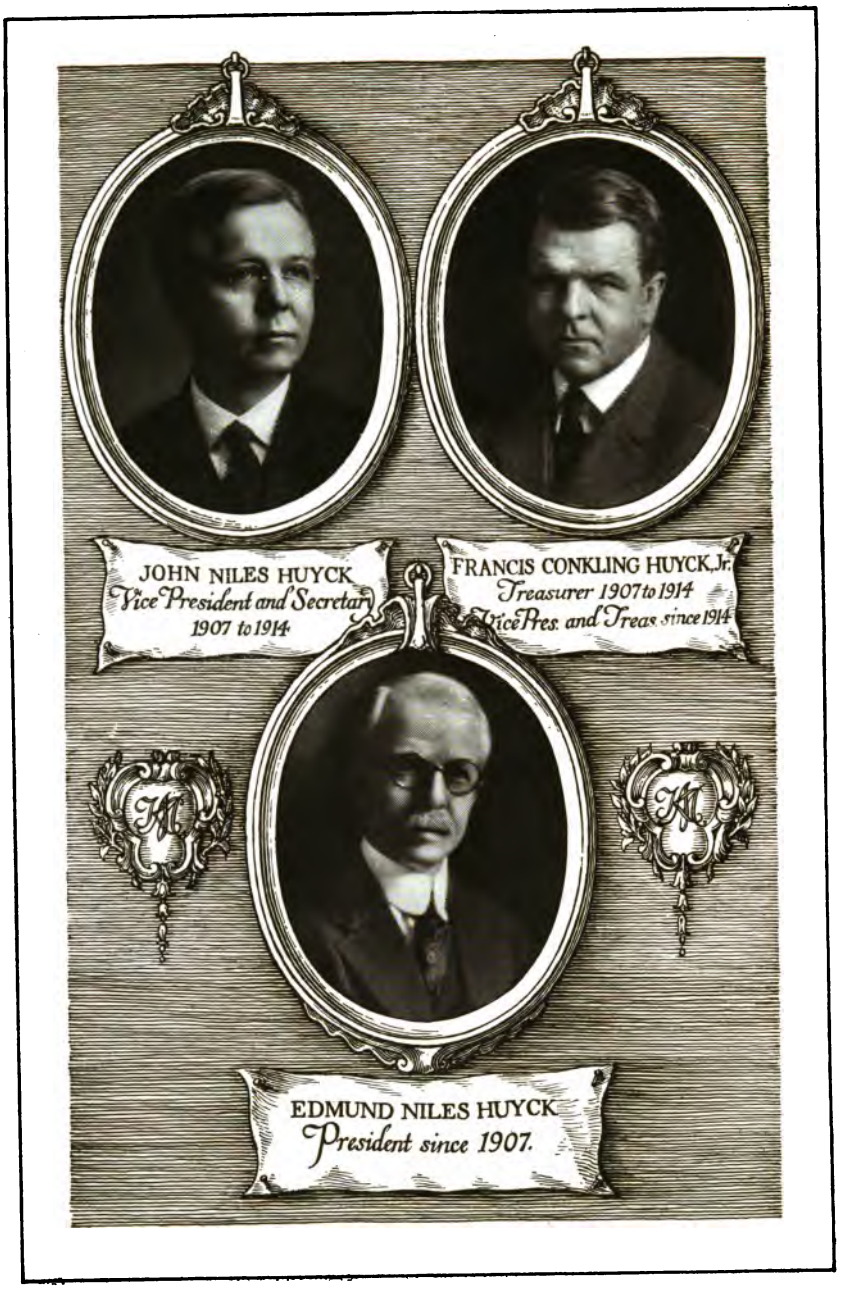
FOREWORD

IT may safely be said that the product of every industry is dependent on the product of some other industry either as a raw material or as a necessary supply in the process of manufacture. The great industry of paper-making has always been dependent on the product which has been known as paper-makers' felts.

From the time when the artisan making paper by hand laid a square piece of woolen cloth over the sheet of paper formed on his frame, and was able by the peculiar properties of the wool fibre to lift the sheet of paper attached to the cloth and transfer it to the pile where by hydraulic pressure the water was removed, to the present where the great endless felts of woolen cloth carry the rapidly moving, continuous sheet of paper through the various press-rolls of the paper-machine at tremendous speed, nothing has been found but this woolen cloth—always known as paper-makers' felts—that would serve this essential purpose. It is not a felt in the true sense of the word, because felt, as it has been made for thousands of years, consisted of the wool fibres pressed and felted or fulled together by the peculiar, half-mysterious tendency of the fibres to interlock, working so closely together that a strong fabric was formed.

The Scythians, who from remotest antiquity roamed about the wastes of Northern Asia, as did their successors, the Tartars, used felt for clothing and tent-coverings; and to-day in parts of Asia the same felted woolen fabric is used for the same purpose.

In paper-makers' felts, however, the fibre being spun into yarn and then woven produces a very different fabric, which received its name of felt from the heavy felting process which followed the weaving, and produced a fabric which might have been more truly called a blanket; but as the name of felt was originally given to it and has survived for more than a hundred years, it will doubtless always con-


JOHN NILES HUYCK
Vice President and Secretary
1907 to 1914
FRANCIS CONKLING HUYCK, Jr.
Treasurer 1907 to 1914
Vice Pres. and Treas. since 1914
EDMUND NILES HUYCK
President since 1907.

tinue to be known as paper-makers' felt, forming the product of an important industry, though one little known to those who are not familiar with the process of paper manufacture.

The purpose, then, of this book is to present the story of paper-makers' felts from the beginning of their manufacture in America about a half-century ago until the present time. The processes in the manufacture of Kenwood Felts will be described, and closely woven with their story will be an account of the development of paper manufacture in America and of the necessary development of felt-making to keep pace with the increased demand for felts to meet the rapidly changing conditions of paper-manufacturers both in quantity and quality of production.

America is the largest paper-manufacturing country in the world, and here since 1870 paper production has been constantly increasing. This increase is because during the last thirty years wood pulp has been used in vast quantities. The rapidity of this growth may be seen from these statistics: In 1869 the American paper-mills had an output valued at $48,000,000; during the next decade the increase amounted to nearly $10,000,000; in 1889 the output was valued at $79,000,000; in 1899, at $127,000,000; in 1909, at $267,000,000; while according to the last census the output is something more than $330,000,000—New York, Maine, Massachusetts, and Wisconsin leading in the production of wood pulp and paper. It is estimated that the production of paper for the year 1918 was $600,000,000.

This advance assumes significance when it is remembered that during the two thousand years that paper has been manufactured, America has produced it only since 1690—that is, a little more than two centuries and a quarter. From tiny paper-mills dotting inland streams the industry has turned to great rivers, to which the forests of the Northern States have contributed millions of tons of pulp to meet the demands of the modern paper-mills. The strides made in the paper industry are well illustrated at the Kenwood Plant in Albany. In the finishing-room, among others, are two dryers. One is a small machine that the plant owned in its early days; the other is the largest dryer that has ever been made. The first was built when paper-machines produced in a minute a piece of paper from one to two hundred feet long and from forty to one hundred and twenty inches wide; the second was designed to meet the needs of machines with speeds of six hundred to one thousand feet a minute, producing paper from two hundred to two hundred and fifty inches wide.

FOREWORD

It is an especially interesting fact that Mr. Francis Conkling Huyck, the founder of the Kenwood Plant at Albany, New York, began in the way hereafter described to manufacture felts in 1870—the year from which may be reckoned the beginning of modern paper-making in America. It is also interesting to note that the first mill on the little stream that flows through the village of Rensselaerville, twenty-five miles from the present location, had similar surroundings to the first paper-mill in America that was established by William Rittenhouse nearly two centuries before the founding of the Huyck Mill.

One of the loveliest spots to-day in the State of New York is the site of the mill in which Mr. Huyck started in the manufacture of felts, which, far back among the rugged foothills of the Catskills, bears an indescribable something typifying the strength of purpose not alone of Mr. Huyck, but of all pioneers who have laid the foundations for great industries.

The founders of the village of Rensselaerville believed that it would become a city because of the value of its water-power. In the last of the eighteenth century, a village located twenty-five miles from Albany was not isolated as were places farther west in the State, and the value of the small water-power quickly brought a number of small industries to locate along the stream as it flowed over a series of falls running through from its source several hundred feet above the village itself. Directly back of the mill that became a felt-mill the fall was one hundred and twenty-five feet. The other falls of lesser height were utilized on the stream below, of which only the grist-mill and saw-mill survive to-day, as small units of water-power are no longer valuable unless most advantageously located on a railroad; but the site of the old mill, while the building itself is gone and only the stone foundations remain, is as beautiful to-day as it was when these same stone walls were laid. Thick foliage and the leaves of wild-grape vines that have clambered over the trees and shrubs almost completely hide the foundations, on which rests one end of a foot-bridge which now spans the stream below the foot of the falls.

Evidences of Mr. Huyck's regard for his native town are seen on every hand: In the beautiful garden of his former home; in the Public Library—his gift to the village; in the Town Hall that was improved by him; in the white church, the tower of which gleams in the sunlight against the purple background of the mountains. But when surveying the great plant built by him in Albany, and his work for his native village, how interesting is the story of the early days of his

venture and his struggle to perfect a new product for the American market.

In the joining-room at the Kenwood Plant to-day a woman is employed who well remembers the first mill in Rensselaerville and the teams of horses that delivered, for joining, the felts to farmers' wives sometimes as far distant from the mill as twenty miles. There were special days for delivery and special days when the felts were collected, and the load was then returned to the mill to be prepared for shipment. In the light of these early conditions the progress in felt-making during the last half-century seems extraordinary. The mill of fifty years ago has expanded into a plant covering several acres, having within its walls the equipment for every process of converting raw wool into felts, and possessing in place of its primitive means of conveyance, its own railroad sidetracks on which the wool is received from far distant lands and the felts are started on their journey to every quarter of the paper-making world.

In presenting this book F. C. Huyck & Sons desire us to dwell not alone on the bare facts of the manufacture of paper and paper-makers' felts during the last half-century, but to present the story in such a way that something of the romance of the industries may be seen. Much has already been written on the early development of the paper industry through Europe and Asia, but in all of these accounts too little has been said concerning the importance of the product. Let it be remembered that paper is the cheapest and most familiar article in use at home and abroad; without it, education would be seriously retarded; without it, the news of the world would not reach the public; without it, letters would not hasten across continents, and yet paper remains the commonest article in daily use—the plaything of the child, the necessity of commerce, the requisite in every business office. In short, it is the medium of progress, intellectual, industrial, social, and commercial; and although the process of manufacture was discovered nearly two thousand years ago, it is still a more important invention than the telegraph, the telephone, the automobile, the aëroplane, or the wireless.

FOOT-BRIDGE AT RENSSELAERVILLE, N.Y.

Thick foliage and the leaves of wild-grape vines that have clambered over the trees and shrubs almost completely hide the foundations of the old mill on which rests one end of the bridge which now spans the stream below the foot of the falls

CHINESE PAPER-MAKING—FIRST PROCESS

ORIGIN AND DEVELOPMENT OF PAPER

ENTURIES ago the Chinese with the subtle magic of the East produced a material suitable for writing purposes that they made from the bark of the mulberry-tree; shortly afterward they utilized rags for paper. And yet the world was old when this important discovery was made. For thousands of years man, born with a desire to express his thoughts, had endeavored to perpetuate great deeds and the lives of heroes. First with rough implements he carved his thoughts in rude characters on rock and stone; four thousand years before Christ he reared against the Egyptian sky tapering obelisks; he adorned the temples and sepulchres with hieroglyphics that told tales of those who had passed. In order to transcribe his thoughts he resorted to beeswaxed board, to the skins and entrails of animals, to the shoulder-bones of sheep, to the skins of serpents. He made parchment—a direct forerunner of paper—and thus bridged the centuries until he discovered the properties of the graceful reed that grew on the banks of the Nile. Thus papyrus

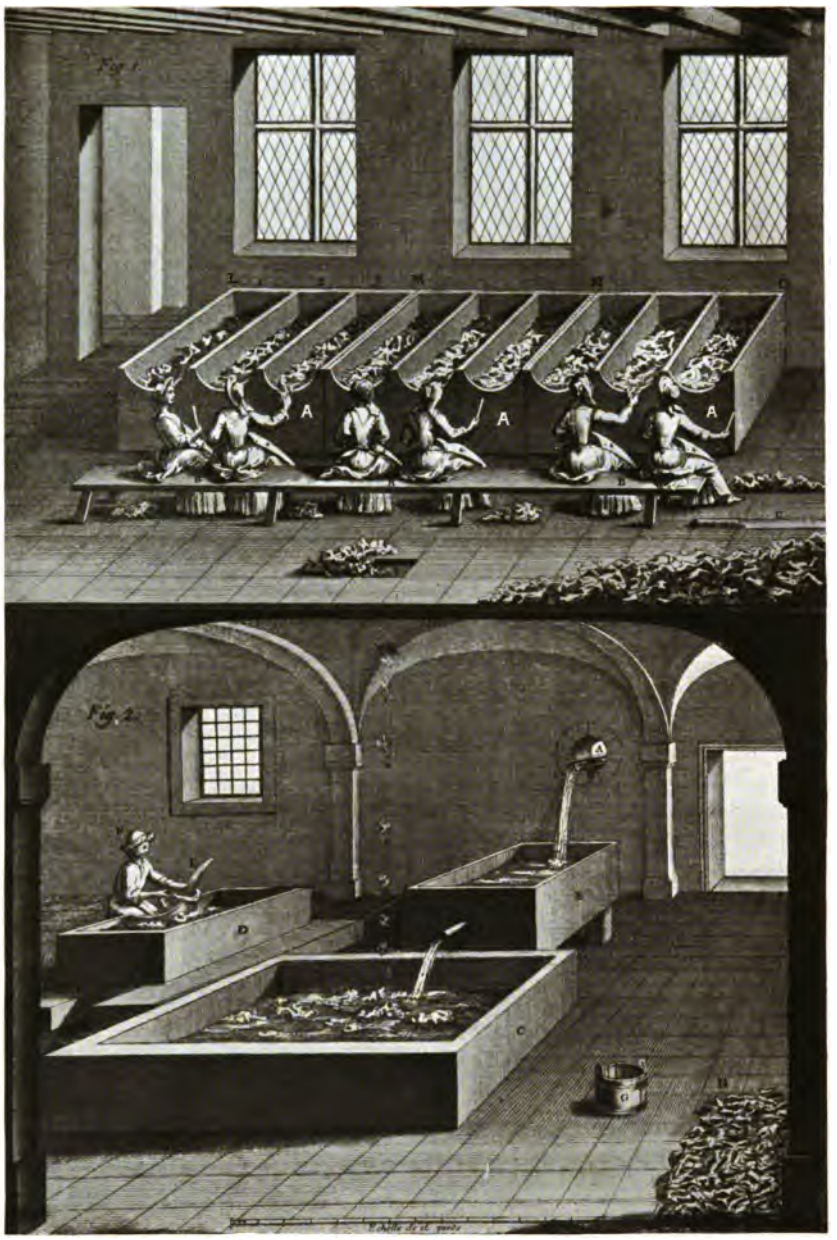
CHINESE PAPER-MAKING—SECOND PROCESS

CHINESE PAPER-MAKING—THIRD PROCESS

marked the first real advance toward modern paper-making, and on it events were recorded until the Chinese marked a new era by the discovery of paper-making.

INTRODUCTION OF THE ART OF PAPER-MAKING INTO EUROPE

How the Arabs after their capture of Samarcand in A.D. 704 stole from the Chinese the secret of paper-making and carried it to their own towns and cities, and how the Crusaders in their turn when they visited Palestine and Syria learned the art which they brought back to Western Europe, has been often told. Europe, however, was slow in developing the industry. It was not until 1189 A.D. that France made paper from pulp. For some centuries the French and Dutch were the leading paper-makers in Europe.



INTERIOR VIEWS OF A SEVENTEENTH-CENTURY PAPER-MILL

Upper picture shows sorting and cutting of the rags prior to the rotting
Lower picture shows serving the rotting-trough

(*See page 5 for description*)

SELECTION OR SORTING OF DIFFERENT QUALITIES OF RAGS, CUTTING-BOX, AND ROTTING-TROUGH

FIGURE I

AAA are three large boxes, each divided into three compartments to separate three different qualities of rags.

1, 2, 3 Compartments for the fine, the medium, and the foul.

BBB Sorting- and fermenting-women who attend in pairs to the three compartments.

1, 2 Knives used by the sorting-women to rake the rags.

C One of these knives viewed separately.

D Coarse paper rags or trace-paper, a mixture of scrapings that the sorting-women throw at their feet.

E Opening through which the rags are thrown into the rotting-trough.

LM, MN, MO. Width of the boxes that receive the rags.

FIGURE II

A Conduit or gutter which supplies water to the rotting-trough.

B Wooden vat receiving the water and serving the rotting-trough.

C Stone vat sometimes serving the rotting-trough.

D Stone box encased in wood in which the rags are cut.

E Back chamfer or blade fixed into this cutting-box.

F Rag-cutter.

G Rag-tub, a small wooden vat in which the rags are carried to the mill.

H Heaps of rags which are in a state of fermentation in the corners of the rotting-trough.

1, 2, 3 Rags falling from the sorting-room into the rotting-room.

PAPER-MILL SITUATED IN GRANDRIF IN AUVERGNE

FIGURE I

A Channel of the stream that supplies water to the mill and to the interior works.

B Willow basket by which the water passes to drain C.

C Drain which supplies the water to the large washing-trough.

D Loop-hole that checks the force of the water and its impurities.

E Large washing-trough where the water is purified.

F Basket across which the water passes into the drain G.

G Drain which supplies water to the small washing-trough.

H Another loop-hole for purifying the water.

I Small washing-trough where the water completes the process of depositing its gravel.

K Grating by which the water passes into the long vat.

L Drain which leads the water to the long vat.

M Loop-hole viewed separately, taken down and out of the reservoir.

N Rack across which the water of the stream arrives on the wheel.

O First gripe, groove, or trough which leads the water to the wheel.

P Conduit, second groove, or trough.

Q Hooks or pins that are unhooked to turn off the water above the wheel.

RR Millwheel.

SS Shaft which raises the hammers. Instead of the iron hoops which should have been represented in the figure, mouldings have been made.

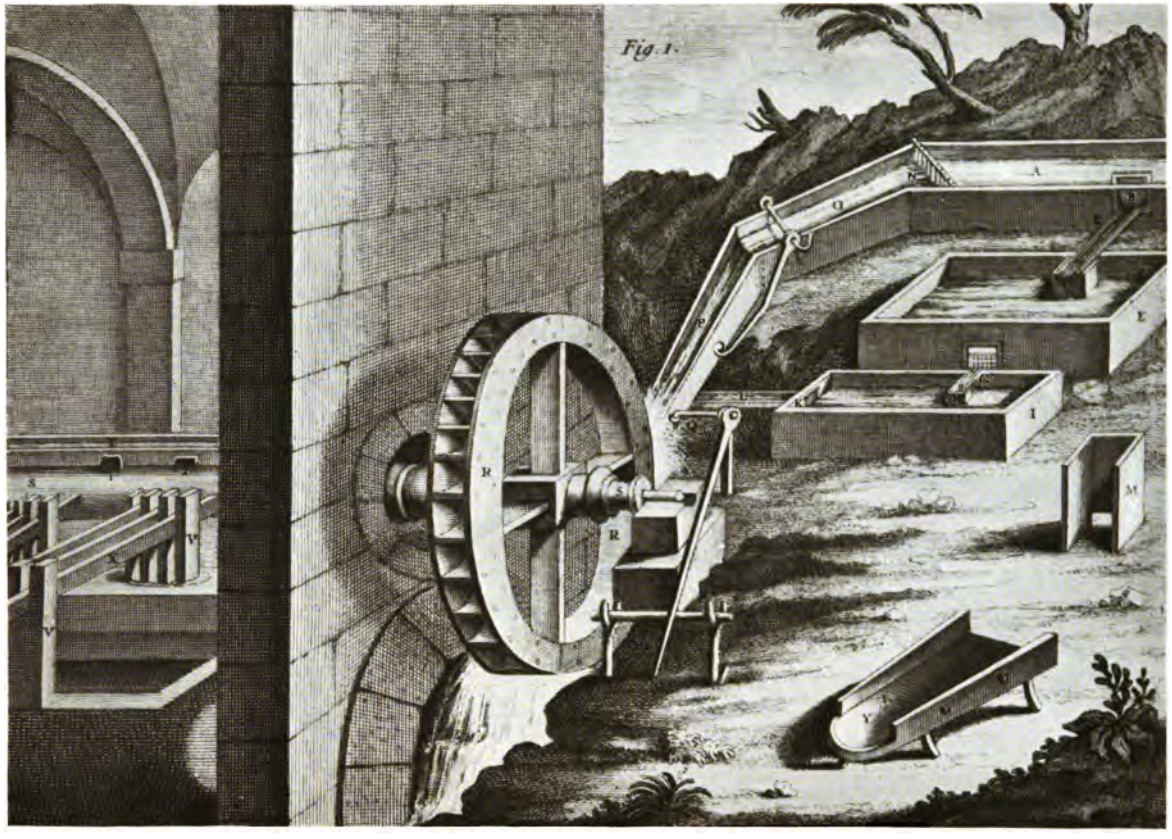
1, 2 Cogs or bolts that raise the hammers.

T Part of the long vat that supplies the water in the stamp-mill.

VV Back and front guides that hold the mallets.

X Mallets which hack or cut to pieces the rags in the stamp-mill.

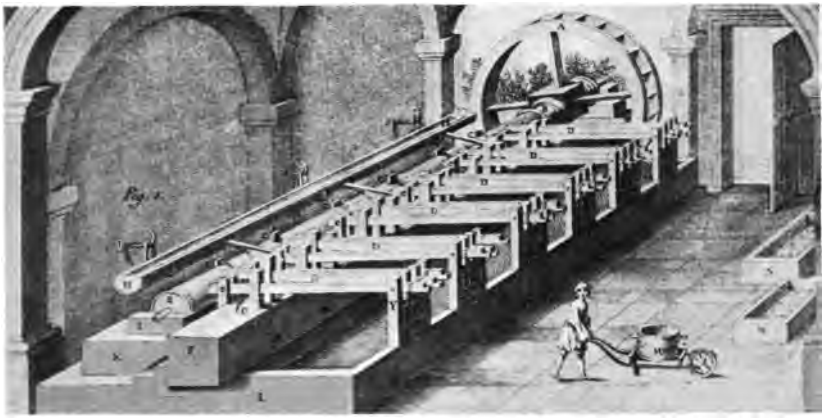
Y Frame in which the felt is washed.



EXTERIOR VIEW OF A SEVENTEENTH-CENTURY PAPER-MILL

Application of water-power

(See page 5 for description)



INTERIOR VIEW OF A SEVENTEENTH-CENTURY PAPER-MILL

Interior of the stamp-mill where the rags are pounded

(*Description below*)

INTERIOR OF THE STAMP-MILL

FIGURE I

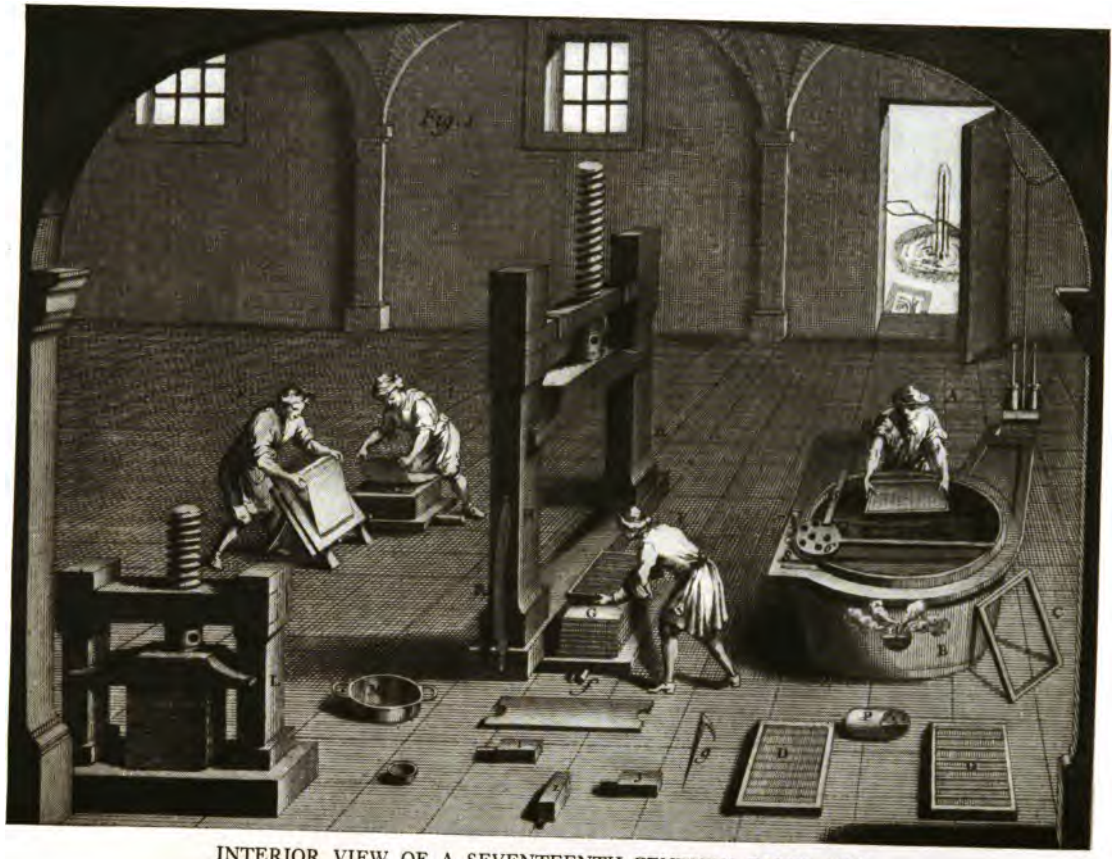
Perspective of the Mill

A The millwheel.
BB The shaft of the bolts.
C Bolts that raise the hammers.
D Mallets, stampers, hammers which pound the rags.
E Front guides which carry the tails of the hammers.
e Back guides which carry the heads of the hammers.
FF Shaft of the vats or stamp-mill in which the vats are hollowed.
G Hollows or stamp-holes.
HH Long vat or conduit which leads the water into the stamp-mill.
1, 1, 1 Hooks which support the long vat against the wall.
2, 2, 2 Channels or conduits which give the water to the tubs.
I Small post.
K Large post.
L The frame of the mill which carries the entire apparatus.
M Rag-tub or -bucket in which is put the refined stuff after leaving the workman's pile.
NN Receptacles or boxes for receiving the rags on leaving the stamp-mill.

PROCESS OF FORMING OR MOULDING, LAYING, AND PRESSING THE SHEETS

FIGURE I

A Laborer, plunger, or opener, standing to his waist on a trestle before the stuff-vat, drawing from the vat his mould filled with a layer of pulp to slide it to the coucher.
B Workman's tub containing the diluted and hot pulp.
b Opening of the kettle which heats the interior of the tub.
C Deckle of the mould.
DD Forms or moulds seen on both sides.
F Coucher who receives the mould filled with a sheet and reverses it on the cloth or felt.
f Lid of the board which is put on the post before pressing.



INTERIOR VIEW OF A SEVENTEENTH-CENTURY PAPER-MILL

Moulding, laying, and pressing the sheets

(*See page 7 for description*)

INTERIOR VIEW OF A SEVENTEENTH-CENTURY PAPER-MILL

Sizing the Paper

(*See page 10 for description*)

G Post or collection of sheets, separated from one another by a felt.
g Hooked tool or stick to draw the post under the press.
HH Press to squeeze the water out of the post.
1, 2, 3 Pieces of wood which serve to load the post when it is put under the press.
5 Small board upon which the mould is slipped.
6 Dropping-board or drainer on which the plunger places his mould.
7, 8 Staves of the dropping-board against which the mould is set.
I Apprentice, felt-lifter, who uncovers each sheet and returns the felt to the coucher.
K Paper-lifter, who detaches the sheets above the felt and places them on the inclined stool upon which he forms the white post.
L Small press where the paper is pressed in white post.
M Copper basin for putting the pulp into the tub.
R Wooden bar or stick used to moderate the force of the press when the lever is turned.

SIZING THE PAPER

FIGURE I

A Workman who raises the basket which contains the waste of the size.
B Workman who passes it through the strainer to separate the dirt.
C Workman who sizes the sheets of paper, wetting them in the sizing-trough.
D Press where the workman deposits the sized paper to get rid of the excess of size.
dd Small spruce boards used by the sizer.
E Lower board of the press in which there is a drain.
F Tub to receive the excess size that flows down the press.
G Vat where the size is boiled.
H Vat where the size is strained.
I Sizing-trough in which the sizing is done and in which a gentle heat is maintained.
K Basket filled with the animal refuse from which the size is made.
L Pulley for withdrawing the basket from the vat.

PAPER HANGING-SHEDS

FIGURE I

A Perspective of a section of hanging-shed.
B Woman who puts the paper in a pile before taking it to the polisher.
C Woman who hangs the paper with her peel.
D Woman who takes off the paper when it is dry.
E Bench for the drying-women.
F Seat which carries the piles of paper when they are spread.
GG Pillars or legs which support the truss of the hanging-shed.

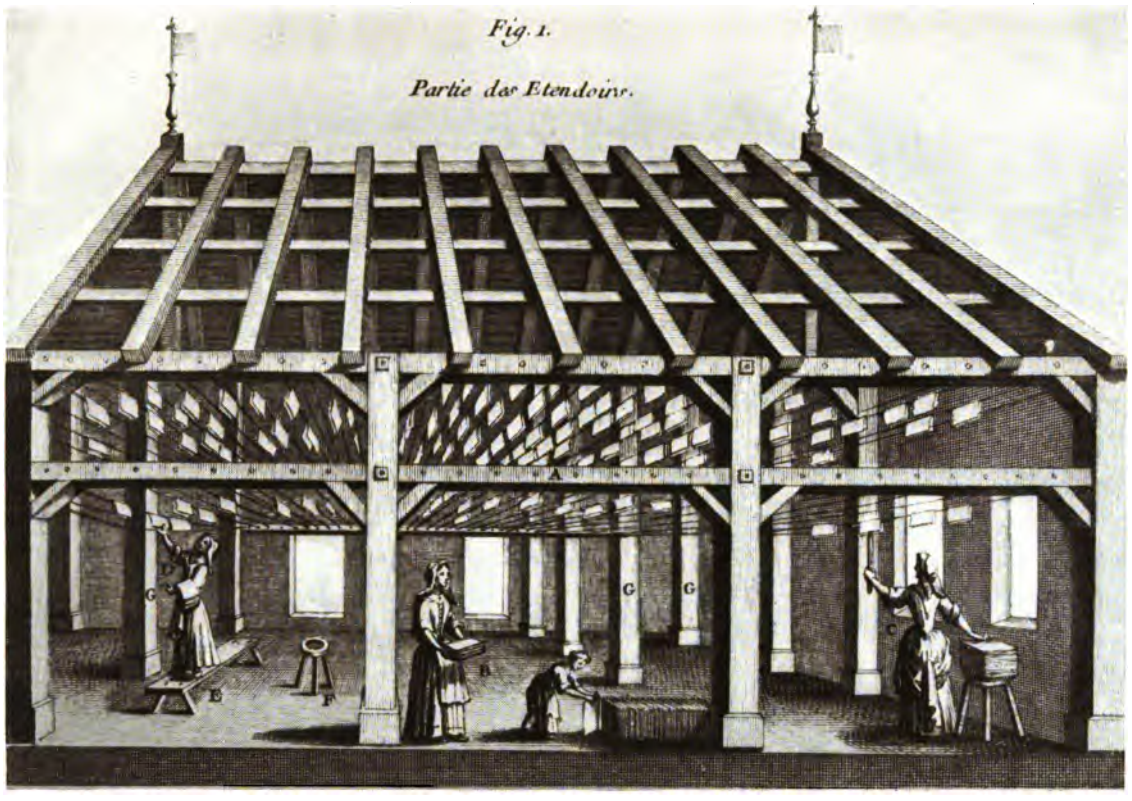
PROCESS OF POLISHING BY HAND AND BY HAMMER; SORTING- AND COUNTING-WOMEN

FIGURE I

AA Polishing-women who rub the paper with a pebble.
aaa Pebbles called polishers.
BB Sorting-women who examine the paper by transparent and oblique light to recognize the faults.
C Sorting-woman who dusts the paper with a knife.
1, 1 Polishers viewed separately.
2, 2 Knives of the sorting-women.
D Piles of paper.

FIGURE II

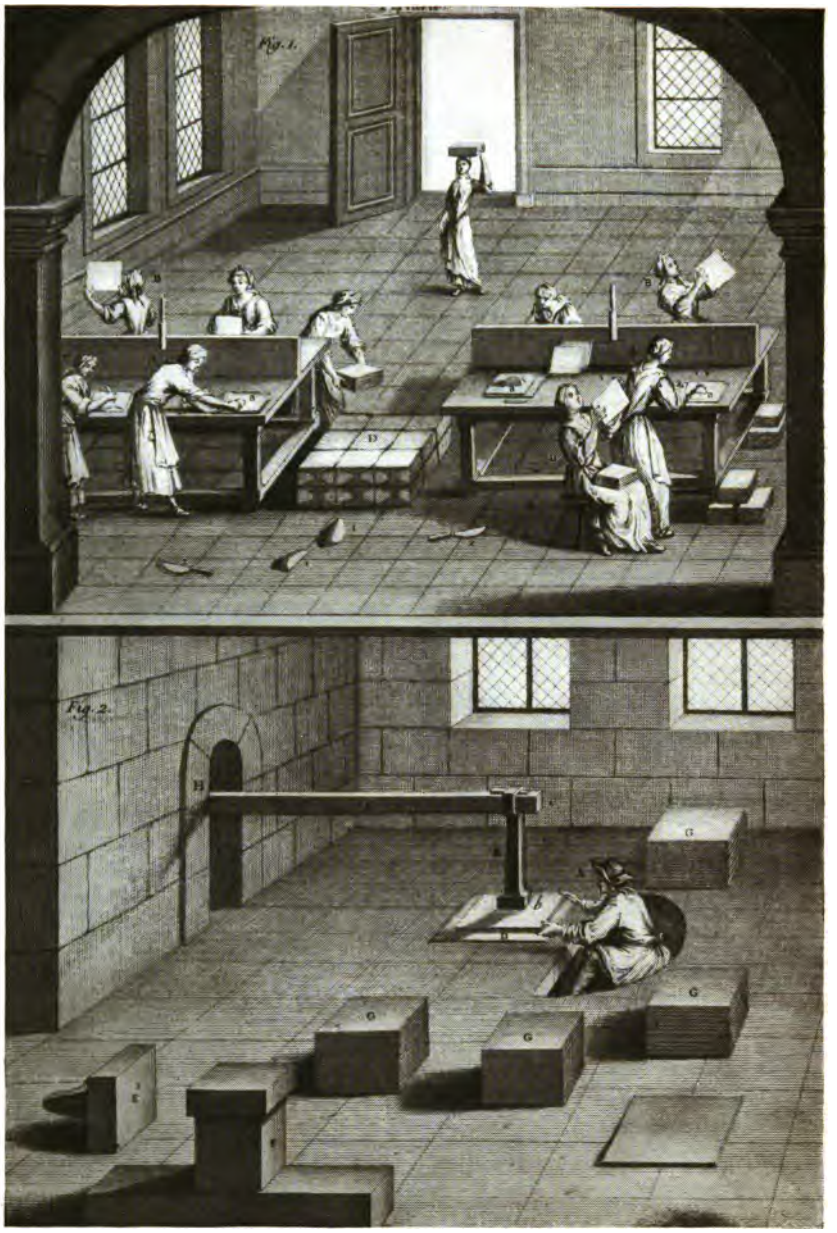
A Laborer who holds the paper under the hammer to polish the large kind.
B Hammer the handle of which traverses the main wall.
b Paper under the hammer.
C Shaft of the hammer moved by water.
D The anvil upon which the paper is placed.
EE The same anvil taken down and shown separately.
F Stock or block in which the foot of the anvil is encased.
G Piles of paper that have been polished.



INTERIOR VIEW OF A SEVENTEENTH-CENTURY PAPER-MILL

Drying-shed

(See opposite page for description)



INTERIOR VIEWS OF A SEVENTEENTH-CENTURY PAPER-MILL

Upper picture shows polishing by hand and by hammer
Lower picture shows polishing large sheets

(*See page 10 for description*)

TWO RELATED INDUSTRIES

FIRST PAPER-MILL IN AMERICA

It is generally believed that the first paper-mill in England was established in 1498—though the first patents for mills were not granted there until 1690, the same year that William Rittenhouse, a native of Holland, and one of the early settlers of Germantown, Pennsylvania, started at Roxborough, near Philadelphia, the first paper-mill in America. William Bradford, a printer of Philadelphia, who afterward established the first printing-office in New York City, was interested in this first paper-mill, which was built on what was then known as Paper-Mill Run and is now included in Fairmount Park in Philadelphia.

The paper at the Rittenhouse Mill was made by hand—as indeed was all paper produced in America during the next century and a quarter—out of linen rags that were manufactured from flax raised in the colony, where the women wove their own wearing apparel. Every sheet of paper was made separately, and several days were necessary in order to finish the product. Bradford, whose vigor and shrewdness were so necessary to the little mill, and who, it is said, had come from England to Pennsylvania for the purpose of establishing a printing-press, had some trouble with the leaders of the colony that led to his departure, in 1693, for New York. With others who had interests in the mill he eventually disposed of his share to William Rittenhouse, who in turn deeded the property to his son, Claus. Before this, however,—in 1701,—the first mill was destroyed by a freshet and a new building had been erected a short distance from the original site. The third Rittenhouse paper-mill was built by a grandson of the founder farther down Paper-Mill Run, and was standing until nearly the beginning of the last century and operated for its entire existence by members of the Rittenhouse family. It is interesting to note that William Bradford, in 1723, introduced Benjamin Franklin in Philadelphia and was influential in securing employment for him in that city.

OTHER EARLY AMERICAN PAPER-MILLS

The second paper-mill in the colonies was built by William De Wees, a brother-in-law of Nicholas Rittenhouse, son of the first paper-maker, and was established near Germantown, Pennsylvania, in 1710. Forty years after the founding of the first paper-mill in America, a

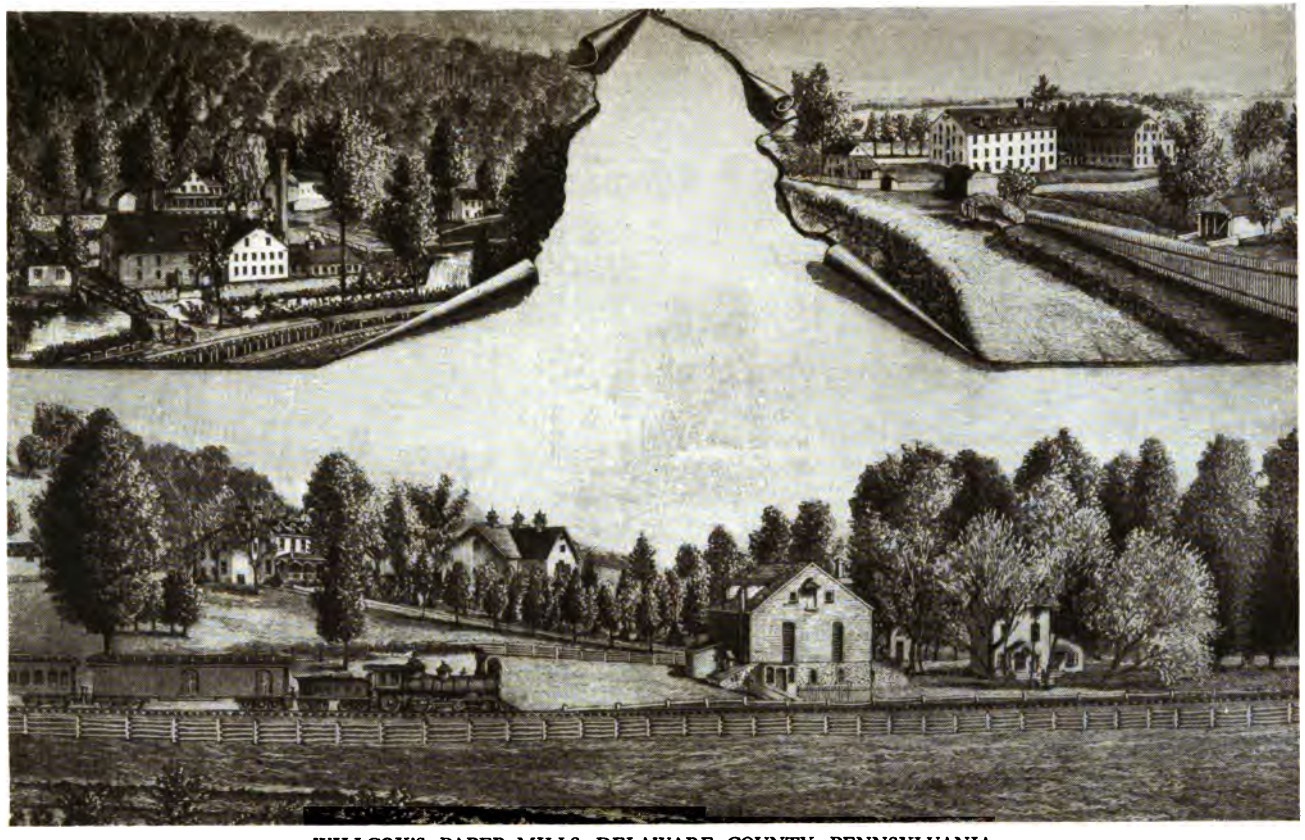
third mill was established by Thomas Willcox, an Englishman, who with Thomas Brown in August, 1729, began to make paper in Chester Creek, about twenty miles from Philadelphia. Mr. Willcox was succeeded by his son, Mark, on whose death in 1827 a local writer, according to Henry Graham Ashmead's *History of Delaware County, Pennsylvania,* says:—

"Two men of two generations, father and son, had conducted the mill ninety-eight years. The ponderous machinery, however, of modern mills silenced it long ago, but it still stands (1884) a silent relic of its early time. Its wheel has long since decayed; its stone gable is thickly covered with the venerable ivy-vine whose root came over the ocean in 1718, from near the old Ivy Bridge in Devonshire."

It was from the Willcox mill that Benjamin Franklin, a friend of Thomas Willcox, procured most of his paper stock and here during the Revolution the Government had its currency made. Again in 1812 the Willcox Ivy Mill supplied paper money.

FIRST MASSACHUSETTS MILL

On September 13, 1728, Massachusetts, which not until this time caught the spirit of Pennsylvania in establishing paper-mills, encouraged the industry by granting a patent to a number of estimable citizens, among them Daniel Henchman, Gillam Phillips, Benjamin Faneuil, Thomas Hancock, and Henry "Dering." These men were given the sole right to manufacture paper for a term of ten years. At present, when the daily production of paper is measured by the hundred tons, it is amusing to learn that one of the conditions granted this little mill for the sole right to manufacture paper was that it should make in the first fifteen months forty reams of brown paper and sixty reams of printing-paper; the second year it must make fifty reams of writing-paper in addition to the first-mentioned quantity; and afterward yearly it must make in addition to the quantity required the first and second year twenty-five reams of a superior quality of writing-paper and produce in all not less than five hundred reams a year. The superintendent of the mill was Henry Woodman, an Englishman. As some one has said, the owners of the mill would be considered a "respectable firm." Daniel Henchman was the leading Boston bookseller of the time; Thomas Hancock was the builder and owner of the historic mansion on Beacon Street, Boston, and the uncle of John Hancock, to whom he bequeathed his estate and fortune;



WILLCOX'S PAPER-MILLS, DELAWARE COUNTY, PENNSYLVANIA

From "History of Delaware County" by Henry Graham Ashmead. Upper left-hand corner shows "Upper Glen Mills," erected 1836. Upper right-hand corner shows "Lower Glen Mills." erected 1845. Lower picture "Ivy Mill," erected 1729

Benjamin Faneuil was the father of Peter Faneuil, who gave the famous hall to Boston; Gillam Phillips married Peter Faneuil's sister, and was a brother of that young Phillips who fought a duel with Woodbridge on Boston Common in 1726. These men decided that they would build their mill in what was then Dorchester but is now Milton, and their venture prospered at first and then apparently died.

Though records give but meagre information, it is known that one Jeremiah Smith bought the mill and allowed it to remain idle. In 1760 James Boies of Boston sent a paper-maker from a British regiment to the mill in order that he might start the work, but the young man's regiment was ordered to Quebec and there he fell while fighting Wolfe. Richard Clark, an Englishman also, was the next foreman. Eventually the mill passed into the possession of Tileston and Hollingsworth, who have manufactured paper in that vicinity since early in the nineteenth century.

FIRST NEW YORK MILL

Among other paper-making enterprises was a mill built in Norwich, Connecticut, in 1768 and operated by Christopher Leffingwell. In this year also the first paper-mill in New York was built at Hempstead on Long Island by Hendrick Onderdonk and Henry Remsen, the enterprise being encouraged by Hugh Caine, a printer. In the South various means were taken to encourage the industry, the Maryland Convention of 1775 offering £400 to one James Dorsett for starting a paper-mill, while in that same year South Carolina offered £500 to any one who would build the first mill. In North Carolina similar measures were taken to encourage the industry that as early as 1776 had been started by German Moravians, who did much toward establishing several forms of productive efforts.

SCARCITY OF PAPER DURING THE REVOLUTION

In spite of all these ventures on the part of the colonists the supply of paper by no means met the demands, and long before the Revolution the situation had become serious and the colonists had already not only pleaded that rags be saved, but that economy be exercised in saving paper during the war.

When General Philip Schuyler wrote in 1775 from Albany to General Washington, he said:—

"Excuse these scraps of paper; necessity obliges me to use them, having no other fit to write on."

The following year when John Adams wrote from Philadelphia to his wife, he adds:—

"I send you, now and then, a few sheets of paper; but this article is scarce here as with you."

The same year Colonel David Gilman of New Hampshire complains that his "officers here make a great complaint for want of paper. They cannot receive the necessary orders, and make proper returns of their company for want of that article."

OTHER EARLY MILLS

To meet these needs various conventions were held and the problem agitated and sifted as best the colonists were able. The first mill built in Central Massachusetts was said to be the best in the country. This was started by Abijah Burbank in 1775, while that of Jackson and Sharpless, built in Western Pennsylvania in 1796, was thought of as a matchless enterprise. At the close of the Revolutionary War it is thought that there were in America about eighty or ninety mills, many of the finest being in Massachusetts. In Springfield, Massachusetts, there was established a mill that during the nineteenth century was developed by the Ames family; in Andover, Samuel Phillips, founder of Phillips Academy, built a mill; and John Ware of Sherburne built in 1790 at Newton Lower Falls, near Waltham, the mill that gave Newton its first and long prestige in the paper-making world.

Paper-mills sprang up in Worcester, Massachusetts; Rhode Island established its first mill in 1780; Connecticut was coming to the front in the manufacture of paper; Vermont, where Colonel Matthew Lyon was the first manufacturer, achieved some fame in the industry; New York's first mill was built on the Poestenkill, a small creek near the Hudson River, a short distance from Troy; while Wilmington, Delaware, in which was located the paper-mill of Joshua and Thomas Gilpin, received special comment from De Warville, a noted statesman of France, when he visited America in 1788. "I have specimens," he said, "both of writing and printing, equal to the finest made in France." Pennsylvania developed the industry rapidly under the watchful eye of Benjamin Franklin, whom De Warville says was the means of starting eighteen mills. William Goddard of Baltimore

aided the industry in his own town, while in Kentucky the enterprise was undertaken by Craig, Parker and Company in 1793.

Immediately following the Revolutionary War, not only were paper-mills rapidly built, but improvements in machinery and processes were introduced, and the first patent law, passed in 1790 for the protection of inventors, gave encouragement to those few who had been experimenting in paper-making. Growth, however, was slow, and for many years America depended on Europe for machinery, and paper-makers' felts were not made here until nearly three-quarters of a century after the passing of the first United States patent law.

THE ERA OF RAGS AND THE INVENTION AND DEVELOPMENT OF PAPER-MAKING MACHINES

The beginning of the nineteenth century marked an increasing activity in the manufacture of paper in America and abroad. From the first little paper-mill with a capacity of one vat in Columbia County, New York, came a call for rags; from the thriving mill of Zenas Crane in Berkshire County, Massachusetts, a similar call was given until the situation was relieved somewhat by the importation of European rags. Mr. Crane, whose mill was founded in 1799 in what came to be one of the great paper-manufacturing sections of America, sent out in 1801 the following appeal for rags:—

AMERICANS!

Encourage your own Manufactories and they will improve.
Ladies, save your Rags!

As the subscribers have it in contemplation to erect a paper-mill in Dalton the ensuing Spring; and the business being very beneficial to the community at large, they flatter themselves that they shall meet with due encouragement. And that every woman who has the good of her country and the interest of her own family at heart, will patronize them by saving their rags and sending them to their Manufactory, or to the nearest Store-keeper—for which the Subscribers will give a generous price.

HENRY WISWELL,
ZENAS CRANE,
JOHN WILLARD.

WORCESTER, Feb. 8, 1801.

EXPERIMENTS ON NEW MATERIAL FOR PAPER

While there were insistent calls for rags in different parts of America, experiments were being made all over the world to procure for paper-making other and new fibres as raw materials. In 1800 the Marquis of Salisbury gave to the King of England a book made of paper manufactured from straw. In this same year Matthias Koops made seven hundred reams of white paper from waste that had previously been thrown away. In Spain at this time there were upward of two hundred paper-mills; in Alsace, France, there were fourteen; and in Jaroslow, Russia, a single paper-mill with twenty-eight machines and seventy vats was manufacturing eleven hundred reams of paper a week and using eight hundred tons of rags a year; while in Germany there were said to be more than five hundred mills in operation.

In 1804 Messrs. Henry and Sealey Fourdrinier began experiments that resulted in the famous Fourdrinier machine, which converted fluid stock into finished paper, and which was introduced into America about 1820.

The Gilpins, famous paper-makers on the Brandywine, were said to be the first to use these machines. Added to the cost of machinery, the shortage of raw material, and the effect of the War of 1812, the paper industry was seriously affected for a number of years.

The Ames family in Springfield continued to do a prosperous business until the panic of 1837 which resulted in the sale of their mills. The business started by Zenas Crane in the Berkshires so flourished that between 1810 and 1825 upward of thirty mills were established in Massachusetts alone. Nearly all the pioneer mills managed, however, to weather the various storms of adversities and to lay firm foundations for the great paper companies that have made the American product famous. At the time the paper-machines were introduced into the United States, about 1820, it was estimated that the average paper production of the mills was about $3,000,000 and the cost of operation was about $2,000,000.

What the succeeding century brought forth, even the greatest seer of 1820 could not have foretold nor the most exalted visionary have imagined. At the beginning of the century marked by that year all of the paper made in America was produced by the long, laborious hand-process, rags forming the fibres. The little mills where this paper was made dotted inland streams. Nearly half of the century passed before wood pulp was proved available, and with its consump-

tion the little mills were one by one abandoned and the industry sought the great rivers that flowed through forests, the one to give the water-power necessary, and the other to yield its virgin growth of spruce for the growing demands of the newspaper world. With the enormous production came some of the greatest engineering feats that the world has ever known.

ORIGIN OF THE FOURDRINIER MACHINE

The period ushered in by the Fourdrinier machine therefore marked an important epoch in American paper production, what might be termed the second era, extending up to the time when pulp was consumed in vast quantities here a half-century later. What is known as the Fourdrinier machine was originally made, though not perfected, by Nicholas Louis Robert of France, who, finding himself impoverished by the French Revolution, sold the patent granted to him by the French Government to François Didot, formerly his employer. The payments made by the purchaser came so slowly that Robert recovered his patent in 1801, but not before Didot had gone to England where he met his brother-in-law, John Gamble, to whom he proposed furnishing capital for the patent in England.

Henry and Sealey Fourdrinier, two flourishing London stationers, were interested in the machine and eventually plans were formed to build the first paper-making machine in England. By 1803 the perfected machines were set up at "Two Waters" Mill, Hereford, and Gamble after suffering severe losses turned over his entire interest in the machine to the Fourdriniers, who, after spending their fortune amounting to about £60,000 on the improved machine, went into bankruptcy, ending their days without money save a small allowance which the London *Times* had raised to aid Henry Fourdrinier.

INVENTION OF THE CYLINDER MACHINE

The manufacture of paper was further aided at the beginning of the nineteenth century by a cylinder-making machine, the invention of J. Dickinson, the founder of John Dickinson and Company, Limited, who conceived the idea of carrying the liquid paper stock in a vat in which was suspended a cylinder covered with a fine wire mesh. As the cylinder revolved, this paper stock was carried in a thin film from the vat to the top of the cylinder, from which point a felt carried it

along to the other parts of the machine. The Fourdrinier machine, on the other hand, which preserves the names of the developers, and which with the cylinder and Harper-Fourdrinier are the principal paper-making machines in use to-day, has an endless wire screen over which the liquid paper stock is poured and shaken until the fibres are spread evenly. The liquid pulp is confined by strips of rubber—otherwise known as deckle-straps—that run along the edges of the screen. The water is gradually shaken through the Fourdrinier wire, or screen, as it passes over a series of suction-boxes, leaving the pulp sufficiently dry to be pressed under a roll covered by a heavy woolen "jacket." It is then delivered to the paper-makers' felt, which receives it in its moist state.

USE OF COTTON AND LINEN RAGS

For a half-century after the introduction of the Fourdrinier machine in America the paper-mills depended for fibre on cotton and linen rags, which are now used only for bond and writing papers. The rags utilized to-day are imported from Europe and Asia and are received at the mills in bales. After being dusted and sorted they are cut up into small pieces and are cooked in boilers containing a solution of lime for the removal of non-cellulose substances. Afterward the rags are washed and reduced to pulp, which is bleached by the addition of chloride of lime. Drainers next receive the solution, which is allowed to stand for about a week, during which the bleach dries and the mass remains a snow-white heap ready for conversion into the fine writing-papers for which America is noted. The remainder of the process is very similar to that undergone in a subsequent account of "a modern paper-mill."

CHANGES MARKED BY THE CIVIL WAR

The Civil War brought a marked change in the manufacture of paper. Like all industries, during the period of conflict the trade wavered, then grew strong again, and by the end of hostilities new machinery was placed in the mills, new mills were built, and gradually the little streams were abandoned and larger water-power sought. The rag supply was again precious, and experiments were made in the use of straw, manila, and finally wood pulp. Frequent attempts had been made in various quarters of the world to use wood for the manufacture

of paper. As early, in fact, as 1826, Italian paper-makers had successfully used the bark of the poplar and willow, the former being found best adapted to the purpose. In 1833 an Englishman had been granted a patent for making paper and pasteboard from wood, and in 1855 another patent was granted in England for the manufacture of paper from pulp.

USE OF WOOD PULP

Nearly a decade after this, paper made from rags and pulp was exhibited in London, and in 1867 a machine was exhibited in Paris for grinding wood pulp. A machine very like this was brought to America and pulp ground first in this country at Stockbridge, Massachusetts, in 1867. This pulp was produced at the rate of about half a ton a day, formed into cakes by hand, and shipped at a price of eight cents a pound to the paper-mills. An important discovery had been made in 1861 by an American named Tilghman, who found a means of dissolving the resinous substances of wood by what is known as the sulphite process. Some years nevertheless passed before wood pulp was accepted as the coming paper fibre. An English journal of 1874 stated that "great endeavors had been made to introduce wood pulp as a fibre, but practical paper-makers deem it a failure. Two kinds are in general use, mechanically prepared and chemically prepared. The great fault of the first is its weakness—after all, it is mere sawdust. The chemically prepared seems a good fibre, but its price, at twenty pounds wet, or thirty-six pounds dry, per ton, is sadly against its use." In America, straw was selected as a successor of rags, rather than wood pulp.

FIRST PULP-MILL IN MAINE AND A MODERN NEWS-PRINT MILL

The first pulp-mill in Maine was the beginning of a large paper and newspaper industry—an industry consuming thousands of cords of pulp wood a year and producing a corresponding number of tons of paper. There is as great a difference between the modern mill and the neighboring original mill at Topsham as there is between the water-power that furnishes thousands of horse-power at the big plant and that of the little stream that pursues its way through Brunswick and Topsham. Down the river, near the modern plant, float the logs that have been cut during the preceding winter in the Maine forests.

Men armed with poles guide the logs on an endless carrier that takes them into the mill, where they are sawed into lengths by means of machinery which is so arranged that the logs come in contact with each other and are peeled and passed through various hands for inspection before they travel down another carrier where they are washed and again returned to the river preparatory to floating down to a second mill. Every precaution is taken to remove knots and dirt and the resinous bark on the spruce that forms the larger proportion of the pulp wood. Two processes follow, the sulphite and the ground wood processes. The sulphite process is one in which the wood, after being cut into chips, is boiled in a solution of sulphurous acid and lime for several hours. The ground wood process consists of subjecting two-foot lengths of wood to a grinding action whereby the wood is pressed against grindstones under heavy pressure and a stream of water played on the stone to carry the fibres away from the stone and to prevent the wood from being scorched. This ground wood pulp is then run through the wet machine, on which it comes in contact with the first felt employed in paper-making. This felt is more or less coarsely woven in order to filter the water that is squeezed from the pulp while passing between heavy rolls. It acts not only as a filter, but as a carrier from one portion of the machine to another. The sheets of pulp that come from this machine are then folded and laid in tiers, where they await mixture with the pulp that has been prepared by the sulphite process. The wood pulp forms eventually the body of the paper, while the sulphite gives the strength.

THE BEATERS AND SIZING

These wood fibres are then passed through beaters, in order to convert them into the finest condition for forming into a sheet of finished paper. A beater is a tub either made of iron or wood provided with a midfeather and backfall. The beater-roll itself is located in one of the channels, and beats and mixes the stock by circulation under the beater-roll, over the backfall, and around through the channel to the beater-roll again. During the beating process, size and filler are added,—in the case of news paper only a small amount of size being used, as the paper should not be too ink-resistant, thus causing trouble in running it off on the machines. The small amount of filler added improves the printing qualities and also tends to improve the color of the finished material. The fibres suspended in a quantity of water

when wrung dry show a substance in which the possibilities of finished paper can be readily seen. The evolution that follows is so rapid that the human eye can scarcely follow the process.

THE FOURDRINIER MACHINE

In an incredibly short time the liquid mass, consisting of about four per cent. fibre and ninety-six per cent. water, is conveyed to the Fourdrinier machine, where it is then mixed with more water and the consistency reduced to approximately 1/10 to 2/10 of fibre to 99 9/10 to 99 8/10 per cent. water. From a feeder head box at one end it is led in a thin milky sheet over an endless wire screen, and kept from running over the edges by the rubber deckle-straps. So fast does the operation take place in the production of five hundred and fifty feet of paper a minute that all that can be seen of the mass is something that resembles a thin sheet of glass that moves rapidly forward while the fibre is shaken sideways and is separated from most of the water by the Fourdrinier wire.

Before the wire passes underneath the couch-roll it passes over a series of suction-boxes where the fibres are sucked down and more firmly interlocked and more of the water removed. At this point it might be well to say that the stock before passing under the couch-roll consists of approximately thirty per cent. fibre and seventy per cent. water. After passing through the couch-roll the sheet is removed from the wire and placed upon a felt which passes between two rolls known as press-rolls, the number of presses through which these wet sheets pass depending somewhat on the grade of stock being manufactured. From the last press the sheet is conveyed to the dryers, where it is kept in close touch with the dryer surface by means of a cotton duck dryer felt. The felt not only acts as a carrier for the paper, but also prevents the wet sheet from cockling when it is brought in sudden contact with the heater surface of the dryers. The paper after passing through the dryers is conveyed to a stack of calenders, consisting of seven or more rolls, where the paper is passed from the top of the stack down through the rolls onto the reels. From the calenders to the reels the sheets are trimmed along both edges and approximately one inch of the deckle-edge is removed. The rolls of paper are then removed and cut into the desired size rolls for large newspapers or sometimes sheeted when they are to be used for pamphlet and small newspaper purposes.

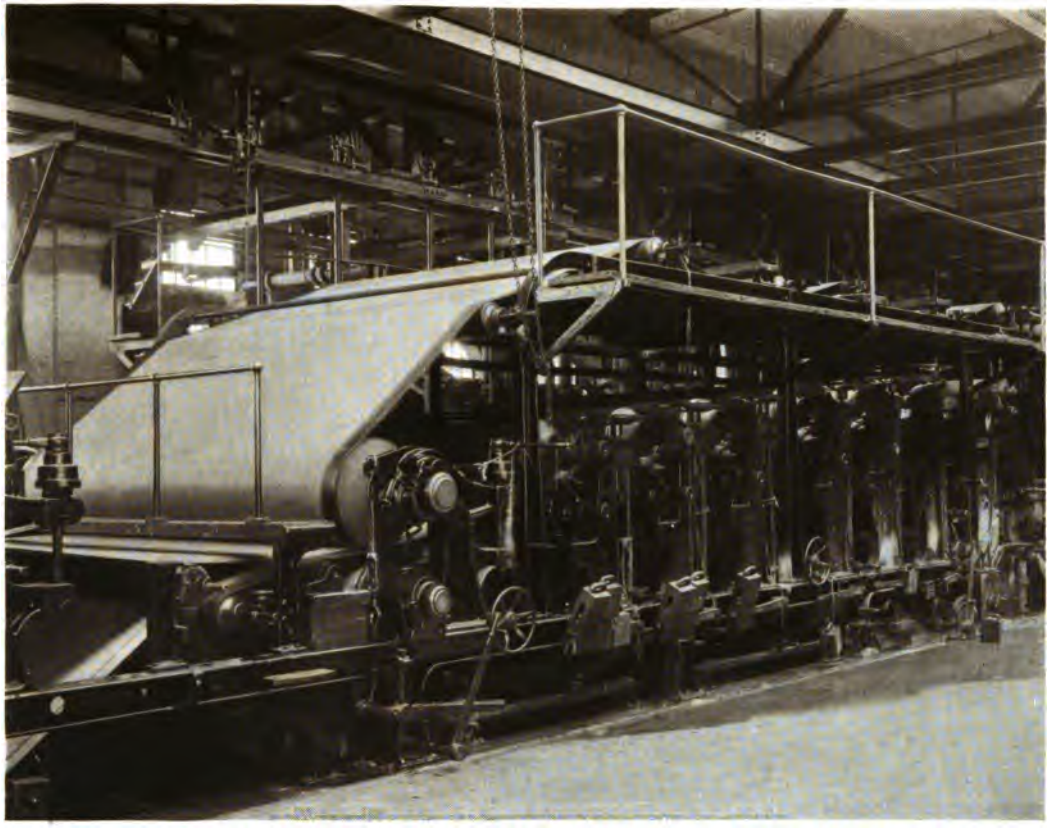
FOURDRINIER PAPER-MACHINE

The part of a big modern Fourdrinier paper-machine over 200 inches wide, on which the felts carry the paper between the heavy press-rolls at great speed

The process of making book paper is much the same as that just described. Different fillers are used, among the most common being clay. The texture of the felts varies—as it does for all grades of paper and machines. After the removal of the reels for book paper, they are taken to the calender-rolls where various finishes are given, the finish depending on the number of chilled-iron rolls used. The coated papers are made by putting the rolls onto a coating-machine that brushes the paper as it is unwound with a combination of casein, blanc fixe, and coloring; and as the paper is unwound it is carried to dryers and hung in festoons until wound on the roll again. The roll is again run through calenders to obtain an extra glazed finish.

CYLINDER MACHINE

Parallel with the wonderful development of the Fourdrinier machine has been that of the cylinder machine from its earlier form, and the paper made by the cylinder process serves almost a greater variety of purposes than that which comes from the Fourdrinier machine. From the making of the coarser kinds of wrapping-paper on cylinder machines, the next development was toward a larger and stronger variety of wrapping-papers. Then, by the addition of more cylinder moulds to the same machine, the product of each mould being taken up by one or more felts and through pressure of the presses being formed into a single composite sheet, this making of a single sheet of several layers made possible the heavy building-papers and roofing-papers and the heavy boxboards which to-day form so important a part of the product of the paper industry. Every day a larger variety of uses is developing for paper-board boxes, and as the old form of straw-paper wrapping gave way to that of the stronger and more serviceable manila, so the wrapping of many articles of merchandise in paper wrappings has given way to the use of boxes. Now, even quite heavy freight shipments are sent in container boxes strongly reinforced by pasting layers of boxboard together or by the process of corrugating. All these new forms of cylinder papers, however, require the use of felts, and in fact no greater test of the felt manufacturers' capacity for improvement has been made than in devising felts that would stand the tremendous strain required from these cylinder machines making heavy papers. Often the strength, almost equal to a leather belt, must be combined with an openness that will filter water freely and with a surface so soft that the pressure of threads will not be left on the smooth



PART OF LARGE CYLINDER BOARD MACHINE

Showing series of baby press-rolls, the first press-rolls and top and bottom felts

PART OF MODERN SINGLE-CYLINDER MACHINE
Showing cylinder mould, felt, and press-rolls

surface of the board. Cylinders have been multiplying until the old one-cylinder machine has now become in many instances a great machine of seven huge cylinders, sometimes producing as much as one hundred tons of board in twenty-four hours. Even the single-cylinder machine which is still being used for making a very great variety of light papers has been developed marvellously in width, in speed, and in every way that would increase its capacity and efficiency.

USES OF PAPER MATERIAL FOR OTHER PRODUCTS

The new uses of paper and the great variety produced, especially on cylinder machines, have made it possible to utilize a large amount of fibre that had previously been wasted. Low-grade wool and cotton rags, old paper stock of all kinds from the finest book and magazine to the coarsest kinds of paper, are each made into useful and serviceable products at the rate of hundreds of thousands of tons annually.

The collection of these fibres alone has become an enormous industry.

This is not a treatise on paper-making, the only desire being to give sufficient account of the various methods of paper manufacture to indicate the general development of the industry and the corresponding necessity for a similar development in the manufacture of paper-makers' felts.

The advance, then, in American paper-making for the past half-century is measured first by an output that has increased many fold,—an advance that may be seen in the great paper-mills of the Northern States, in the enormous consumption of wood pulp, in the utilization of the great water-powers of the North, surpassing anything that the original mills with their slowly turning water-wheels or the later mills run by steam ever dreamed of. To enlarge the great industry master minds have perfected machinery and equipped great plants, Nature has yielded her forests and power-producing waters, and the world has been the beneficiary of all these productive improvements.

USE OF FELT IN PAPER-MAKING
GREAT STRIDES IN THE INDUSTRY AND SOME INTERESTING STATISTICS

From the earliest days of paper manufacture felts of pure wool have been necessary in order to press out the water adhering to the fibres. These felts in the early days were pieces of woolen cloth cut to the size of the "moulds." In the hand-made process the paper-maker used a wire screen or mould that was rectangular in shape and supported by a framework of wood. A shallow frame known as the deckle was placed on top of the mould. The sheets of paper were formed by dipping the mould into the pulp, the workman filling it even with the top of the deckle, where, after draining, it was taken off in sheets and laid between pieces of felt which were pressed until the sheets of paper were ready to be dried still further on lines or poles.

With the introduction of machinery a century ago, the Fourdrinier and cylinder machines were equipped with sheets of felts that were made into belts by sewing the ends together. More than half a century elapsed before felts were joined and a still greater time before endless felts were woven. The paper-makers' felt has three distinct functions: first, to couch the paper, or, in other words, to pick it up

from the cylinder or from the Fourdrinier wire; second, to act as a carrier to succeeding parts of the machine; third, to act as a filter, allowing water pressed from the paper to pass through its meshes and run away, thus aiding the drying process. The durability of paper-makers' felts are reckoned either on the days run or the number of pounds of paper made.

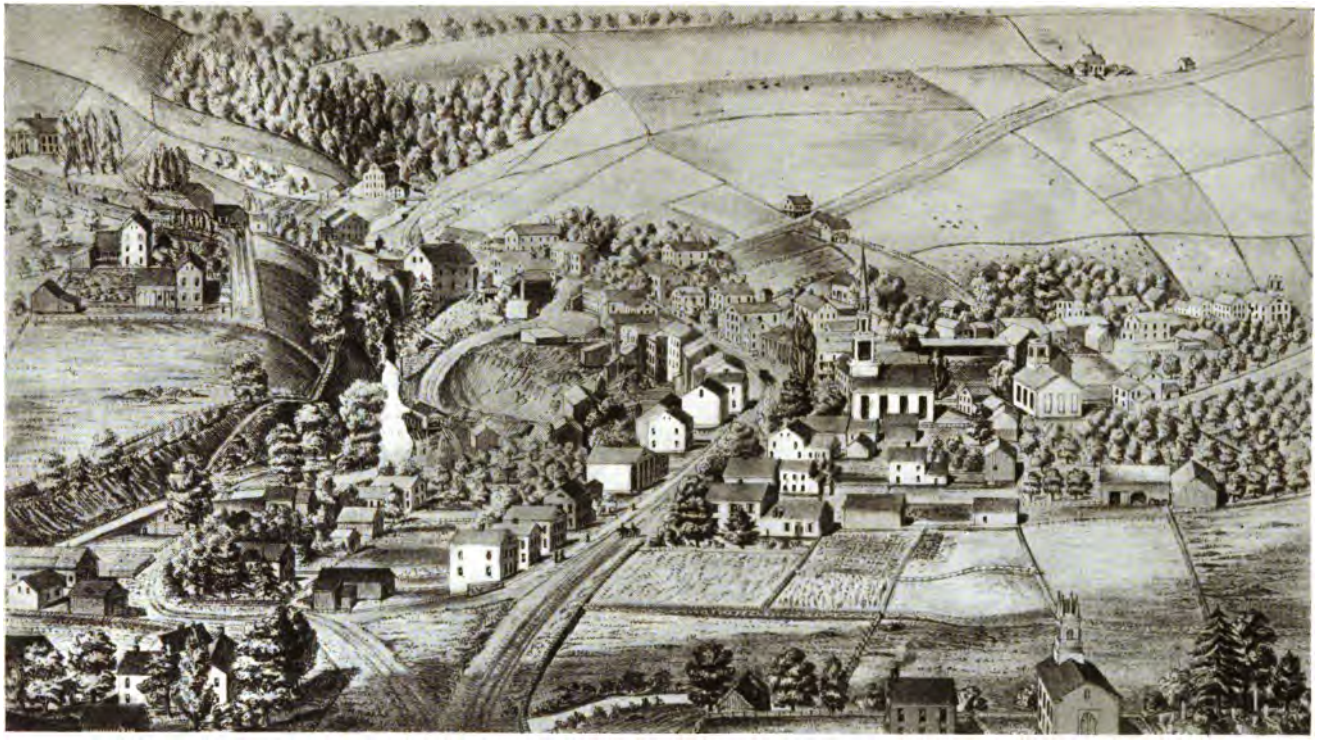
PIONEER COMPANIES

For nearly half a century after the introduction of Fourdrinier and cylinder machines in the United States the paper-makers' felts used on these machines were imported from Europe. As early as 1854 Asa Shuler of Hamilton, Ohio, made piece felts for paper-makers, and on learning from an Englishman the process of making belts of felt, Mr. Shuler began their manufacture about twelve years later, and with Mr. John W. Benninghofen formed the firm of Shuler and Benninghofen.

THE BEGINNING OF THE MANUFACTURE OF PAPER-MAKERS' FELTS

In 1864, however, a group of enterprising Americans, among whom were Albert Johnson, Samuel T. Thomas, Andrew Fuller, and Charles C. Newcomb, established a new business on this continent and under the name of Johnson, Fuller and Company began to manufacture felts. They leased and equipped with machinery, which they gradually perfected, a small mill at Camden, Maine; and so successful was their venture that within a short time the concern became a stock company and the name was changed to the Knox Woolen Company, under which title it still continues to do business. Another of the four original firms of paper-makers' felts was F. Gray and Company of Piqua, Ohio. The fourth original firm was that of H. Waterbury and Company of Rensselaerville, New York. The last-named firm was established at a unique period in the history of American paper-making —the beginning of the era of modern paper manufacture. Twenty years, however, were to pass before the great impetus took place that established America at the head of the paper-producing countries of the world.

At this time startling discoveries were made that vanished almost as soon as they were talked of. In this eventful year 1870 a sensation was caused by as simple an invention as a paper petticoat that



RENSSELAERVILLE

From a sketch of the village drawn about 1865

was put on the market at fifteen cents the garment; a French inventor claimed at this time that he could cleanse paper so that, all ink removed, it could be again used as fresh stock; one Jefferson Evart patented a process he had discovered for reducing pulp for the manufacture of coffins; in New York alone rags were imported to the amount of 104,661 bales valued at $2,149,202; of the one hundred and fifty-six paper-mills in Holland in the year 1870, only about ten made paper by machinery; the manufacture of paper collars in Boston during this year amounted to seventy-five million; there were six hundred and sixty-nine paper-mills in the United States at this time; owing to the alarm concerning the scarcity of paper fibre a short time before this eventful 1870, fish were used to produce pulp; all importation from France had been stopped owing to the war, and for a time panic existed in America because many of the great paper-mills closed owing to the scarcity of water; it was in 1870 that the Mobile *Register* was printed on paper manufactured from the okra plant; while the consumption of esparto had risen on the continent to one hundred thousand tons a year.

SOME PAPER STATISTICS

Four years after H. Waterbury and F. C. Huyck began to manufacture felts at Rensselaerville, the following data were compiled of the number of mills in the various countries where hand-made paper was produced: Africa, 1; Austria, 130; Belgium, 19; Brazil, 11; Canada, 2; Denmark, 5; France, 404; Germany, 423; Great Britain, 273; Holland, 110; Italy, 97; Norway and Sweden, 20; Portugal, 16; Russia, 66; Switzerland, 30; Spain, 17; United States, 467.

Various experiments were still carried on. Papyrus, that was believed to be extinct, was cultivated as a rare plant in the Kew Gardens and at the Royal Society's Gardens in London. An extraordinary attempt was made by E. Waters and Son of Troy, New York, to construct a canoe of paper weighing fifty-eight pounds, that was destined for a voyage from Albany to the Gulf of Mexico. While the paper situation of 1876 was being agitated, one Carl Engel made the following paper estimate:—

"Of the 1,300,000,000 human beings inhabitating the globe, 360,000,000 have no paper or writing material of any kind; 500,000,000 of the Mongolian race use a paper made from the stalks and leaves of plants; 10,000,000 use for graphic purposes tablets of wood;

130,000,000—the Persians, Hindoos, Armenians, and Syrians—have paper made from cotton; while the remaining 300,000,000 use the ordinary staple. The annual consumption of this latter number is estimated at 1,800,000,000 pounds, an average of six pounds to the person, which has increased from two and two and a half pounds during the last fifty years. To produce this amount of paper 200,000,000 pounds of woollen rags, besides great quantities of linen rags, straw, wood, and other materials are yearly consumed. The paper is manufactured in 2,960 mills, employing 90,000 male and 180,000 female laborers."

SMALL AMERICAN PAPER-MACHINE

Installed at the Japanese Imperial Government Paper-Mill in 1878 and still running. Modern machines have since been installed

THE MILL AT RENSSELAERVILLE

Where Francis Conkling Huyck started the manufacture of paper-makers' felts in 1870

FOUNDING THE KENWOOD MILLS

AN attempt has been made in the last few pages to present the changing conditions that existed at the time of the founding of Messrs. Waterbury and Huyck's mill in 1870 on the little stream that tumbles down from the hills and pursues its way through the village of Rensselaerville, New York. That mill and stream are illustrative of the size of the woolen- and paper-mills of that day. Fifty years ago there were no big pulp- and paper-mills bordering the forests, and modern engineering feats were undreamed of. Mr. Henry Waterbury had come to Rensselaerville from Schoharie to take up the manufacture of woolen cloth in the woolen-mill that had been built at the upper end of the little village in the early part of the century. This mill had replaced one erected in 1794 on the same site, the purpose of which had been to receive wool from neighboring farmers, carding it into shape called rolls, which were then returned to the farmers to be spun into yarn and woven into cloth. This cloth was again sent to the mill to be felted or fulled and finished, after which it was returned to the owners and made into the families' clothing. Even after Mr. Waterbury was operating the mill, rolls were still made for the farmers, though the yarn spun from them was then usually used for knitting stockings. Mr. Waterbury discovered the use of paper-makers' felts and the method of making them, and especially the secret of joining them, which was most important of all. He believed there was a future in this new industry and proposed to Mr. Huyck that he should join him in the effort to manufacture paper-makers' felts. Mr. Huyck's friends tried to persuade him not to venture on a field so new and precarious, but he too had faith in the new enterprise and decided to take the risk. At the time when it was proposed that he enter the manufacturing world he was in business with his father, in a general country store at Rensselaerville. His assets, when he definitely decided to enter business with Mr. Waterbury, were a small amount of capital,

the ability of a good salesman, and a gift of business vision which in later years proved very valuable when he came to establish the modern plant at Albany. It must not be imagined that Mr. Huyck took the step rashly. He prepared himself well for it by going about among many of the paper-mills and making inquiries concerning the use of felts, where the felts were bought, how much was paid for them. Of weaving he knew little, but his knowledge of selling and of business possibilities was comprehensive and accurate. There are few mills such as Mr. Huyck visited remaining in New York, or probably in the United States. A typical mill—indeed a mill that was undoubtedly visited by Mr. Huyck—is the Centennial Mill at Valatie, New York, where for more than half a century straw wrapping-paper has been made. A description is not uninteresting.

A TYPICAL STRAW-PAPER MILL OF THE TIME

The Centennial Mill is unique and picturesque, its red brick walls sloping down to the little stream that supplies its power. Pyramids of straw await conveyance to the deep old vats which are fitted with steam-pipes to keep the straw at a given temperature during the eight or ten hours that are consumed in the cooking. The beaters on a lower floor prepare the straw for entrance to the cylinder machine that

CENTENNIAL MILL, VALATIE, NEW YORK

travels at about one hundred feet a minute and turns off the crisp brown sheets of wrapping-paper that at one time formed the only wrapping-paper in use. Mr. Huyck's interest in this mill may have arisen not only from the information he desired to glean concerning felts, but from the fact that at his father's store many and many a time had he done up groceries in that sort of wrapping-paper, no paper bags being then in use.

F. C. HUYCK ENTERS BUSINESS

As a partner in the firm of H. Waterbury and Company, Mr. Huyck entered the business. For eight years, from 1870 to 1878, the struggle followed to put their paper-makers' felts on the market. The company was handicapped in innumerable ways. They were short of help, a long distance from a railroad, and they were selling a new product. Much labor was expended in conveying the felts, after they were woven, to women along the countryside, that they might join the felts and return them to the mill for washing and fulling and finishing. After eight years of constant effort Mr. Waterbury decided to remove to another part of the State, and was more or less astonished when, on stating his expectancy of Mr. Huyck's accompanying him, the latter said that he intended going to Albany to start a plant of his own for the manufacture of paper-makers' felts. He rented a mill at Kenwood, a suburb two miles from the centre of Albany, and began manufacturing in 1879.

Mr. Waterbury, in pursuance of his plan, established at Oriskany, New York, the firm of H. Waterbury and Sons. From time to time many enlargements of the original plant have taken place, and the firm of H. Waterbury and Sons Company is to-day one of the eleven important plants manufacturing paper-makers' felts. A few years ago two of Mr. Waterbury's sons and their associates established a new plant at Skaneateles Falls, New York, the Waterbury Felt Company.

The F. Gray Company through reorganization became the Orr Felt and Blanket Company, which is still located at Piqua, Ohio. In 1895, the Albany Felt Company, Albany, New York, was formed by Mr. Parker Corning and Mr. James W. Cox, with Mr. D. M. Fuller as superintendent. The Appleton Woolen Mills of Appleton, Wisconsin, centre of a great paper-manufacturing district, decided to take up the manufacture of paper-makers' felts and joined the number already in the industry. Draper Brothers of Canton, Massachusetts, an old

FALLS ON THE TEN MILE CREEK, RENSSELAERVILLE

Which supplied the power to the woolen-mill

established firm of woolen manufacturers, likewise entered into the business somewhat later. The Lockport Felt Company of Newfane, New York, was formed to manufacture paper-makers' felts, as was the Philadelphia Felt Manufacturing Company, both these concerns continuing at the present time in the industry. Several other plants were launched in the manufacture of paper-makers' felts, but for one cause or another have discontinued, and those above mentioned with the original firms of Knox Woolen Company, Shuler and Benninghofen, and the firm of F. C. Huyck and Sons, who are the successors to the business founded by Mr. Francis Conkling Huyck, are the eleven successful and important concerns now engaged in the manufacture of paper-makers' felts.

THE BEGINNING OF THE KENWOOD PLANT

Mr. Huyck while engaged in business in Kenwood took into partnership Mr. Chauncey Argersinger, and the firm of Huyck and Argersinger was formed. They were fortunate in securing as superintendents Mr. Andrew Fuller, one of the founders of the Knox Woolen Company, and his son, Mr. Duncan M. Fuller.

The period at Kenwood was one of successful development, lasting from 1879 to 1894. The mill rented by Mr. Huyck had been a knitting-mill. There were some cards and a few spinning-machines of the type that marked the period between the hand-type of spinning-machines and the self-operating type. These were used for a number of years. The period at Kenwood covered the change from the slow-running methods of making paper to the fast machines. It also marked the transference of newspaper plants to the edges of the forests; it also marked the shifting of the centre of the industry to the Middle States, to Maine, and to Canada. Changes also occurred in the manufacture of felts. As the machines became wider the necessity for wide looms and wider finishing-machines grew. The extreme growth in the width of machines took place later. The speed of paper-machines during this period increased from one hundred and twenty to two hundred and fifty feet a minute.

NUMBER OF PAPER-MILLS

At the time of the establishment of the plant at Kenwood the number of paper-mills, according to *Lockwood's Directory of the Paper Trade,* in the United States was reckoned at nine hundred and

thirty-four, the number of firms at seven hundred and ninety-five. Of these two hundred and fifty-four firms and three hundred and twenty-seven mills were located in the Eastern States, three hundred and twenty-eight firms and three hundred and sixty mills in the Middle States, one hundred and fifty-five firms and one hundred and seventy-nine mills in the Western States, and fifty-eight firms and sixty-eight mills in the Southern States. At this time many associations were being formed by those active in the paper trade, and the first of these was brought together in 1878 and named the American Paper Manufacturers' Association. This organization grew out of a convention in that year, the name being eventually changed to the American Paper and Pulp Association, which included on its membership list all of the men actively interested in the paper trade who thus joined together to establish prices and keep in touch with the market. The first American paper trade journal had been established in 1872. It was called *The Paper Trade Journal* and was founded by Mr. Howard Lockwood.

PLANT AT KENWOOD BURNED MAY 4, 1894, AND REMOVAL TO RENSSELAER

The second epoch ended, and the third in the history of the Kenwood plant began on May 4, 1894, when the entire mill was destroyed by fire. Scarcely had the ruins crumbled to ashes when a new site—the present one—was selected at Rensselaer across the Hudson River from Albany. The new plant was completed, equipped with machinery, and started on October 16th of the same year. It was at this time that Mr. Argersinger, the partner of Mr. Huyck, retired from the business. Mr. Huyck then formed a partnership with his sons, Edmund N. Huyck, John N. Huyck, and two years later Francis C. Huyck, a third son, under the firm name of F. C. Huyck and Sons. The name of Kenwood Mills that designated the felts, and had been taken from the former location of the plant, was retained and has been used ever since to distinguish the products made by the firm.

Under the guidance of Mr. F. C. Huyck, during the next ten years, the plant grew rapidly. The prophetic vision of his youth remained undimmed, and he was constantly on the alert for new methods and new machinery. His undaunted belief in the future of the felt-making industry served as an inspiration in everything that he undertook. An English writer has said of Mr. Huyck: "If a new and improved machine was invented, he bought it at once. If new conditions arose

THE KENWOOD MILLS

At Kenwood, a suburb of Albany, 1878 to 1894

in paper manufacture, he was eager to meet them. He always felt that his business deserved the best machinery and best methods, and demanded of his sons and of all those associated with him that these be secured and adopted. For example, once when travelling in England he learned that raising or napping machines with revolving teasels had recently been invented. On his return he at once induced a manufacturer of textile machinery to make these improved machines and replaced all of the old style. At another time he learned while in Europe that a loom had been designed and perfected for weaving felts seamless. Before his return he had ordered several of these looms for trial. They were so successful that Mr. Huyck sent one of his sons to purchase more looms and secure their exclusive use in the United States. This was accomplished, and I found the mill equipped with a large number of these looms all weaving seamless felts. I was informed that the growing demand for their seamless felts is remarkable. On high-speed machines, felts must often be strained very tight to keep them open and, as is well known, a hand seam is the first point in a felt to give way. In seamless felts this weakness is entirely eliminated."

PRESENT OFFICERS

Francis Conkling Huyck's death occurred on July 4, 1907, after he had established a business that was known on both continents. The company was shortly afterward incorporated, the eldest son, Edmund Niles Huyck, being made president; John Niles Huyck, the second son, vice-president and secretary; while the youngest son, Francis Conkling Huyck, was made treasurer. John Niles Huyck died October 31, 1914. The sons endeavored to the best of their ability to continue the policies of their father and to maintain the standards that he set for progressive development.

This is not a story of individuals or individual achievements. Aside from the facts which it has seemed fitting to write of the founder, it is the story of the growth and development of a business. Its success and the importance it has attained in the industry are the result of the efforts of hundreds of men and women working through all these years in harmony and with a spirit of co-operation. Steadily the number of workers has been increased, foremen have been engaged or promoted; skilled accountants, men trained technically in this textile industry, salesmen of high character and ability, and executives

THE KENWOOD MILLS, RENSSELAER, N.Y. (OPPOSITE ALBANY), 1919

As this book goes to press a large addition to this plant is under construction

of wide experience have joined the organization and are to-day inspired by the same ideals of progress and service.

The gradual exhaustion of the wood supply in the United States has made it necessary to build more and more paper-mills, that the increased demand for newsprint paper may be met, and these mills are growing rapidly in Canada on the various waterways that exist from Newfoundland to British Columbia on the edges of the great spruce forests. Canada is therefore constantly becoming a much more important paper-manufacturing country and is destined to supply a large part of the world's supply of paper made from wood. In 1918 F. C. Huyck and Sons decided to establish a plant in Canada. A mill was procured at Arnprior, Ontario, thirty-eight miles west of Ottawa, on the line of the Grand Trunk and Canadian Pacific. The mill had been built for making felts. The owners were willing to sell this plant and it was purchased in July, 1918. An addition was immediately started and machinery purchased, and now at this plant is made the same quality of felts as in Albany. The addition was completed late last year and another addition is now being constructed for extra space that is already needed. The Canadian plant is incorporated under the name of Kenwood Mills, Limited.

A STORY OF WOOL AND THE FIRST KENWOOD PROCESSES

Wool comes to the Kenwood plant at Rensselaer from all over the world. The storehouses in which this wool is stored in bales are near the main line of the New York Central Railroad, from which a side-track has been built that leads direct to the plant. Order and capacity are the most impressive features of these storehouses which the world supplies, and which, in turn, give out the wealth of their stores to supply the wool-room.

The wool-room is the most cosmopolitan part of the plant. Not cosmopolitan in the sense of race—for nearly all of the assorters are men who originally worked in English mills and who came to America years ago. Many of them are men who breathed the fresh air of English hillsides until the mills of England claimed them. Their school has been the school of experience and their principal qualifications as assorters are experience and good eyesight.

"They must be capable," says their foreman, "of sorting both fleeces and badly graded pulled wool; they must be able to make as many sorts as are required—sometimes five or six from a single fleece; they

ARNPRIOR PLANT, ARNPRIOR, CANADA

PILE OF WOOL

must judge the differences, not only by length of fibre but by size of fibre."

But in the many countries of the earth from which the wool is imported, the cosmopolitan qualities of the wool-room are unmistakably shown. Since a flock of domestic sheep cannot be depended on for the manufacture of felts, it is necessary to draw from many places in order that there may be secured texture and length of fibre. If a botanist were to go into this wool-room he would in most cases be able to tell exactly from what country various fleeces had been brought, for these fleeces come to the mill with the burrs of their native lands clinging to the wool fibres.

WHERE THE WOOL COMES FROM

One man picks up a fleece and after examining it says:—

"Oh, yes, Australian wool. We call her the 'Land of the Golden Fleece.' She pastures a hundred million sheep and produces annually more wool than any other country in the world. Here are burrs and

vegetation of the wide, dry pastures of Australia clinging to this fleece. In this vegetation there is a quality—the character of which you can see somewhat from these dry shreds that still cling to the wool—that acts as the Trent does on Bass' Ale. That is why the country has the reputation of producing the finest wool in the world. You know, I suppose, the story of how sheep were first raised in Australia? No? Well, the pastoral industry was founded by Captain John M'Arthur, who was connected in some official capacity with the convict station at Fort Jackson. While there, he conceived the idea of raising sheep in New South Wales which he considered well adapted to the purpose. He couldn't get merinos from Spain, for their exportation was forbidden, so he procured half-bred merinos, and from the Cape he managed to get three Spanish rams and five ewes. By the early part of the nineteenth century his flock had increased to nearly seven thousand sheep. It was during the Peninsular War that the King of Spain presented George III with a small flock of selected Spanish sheep, and in some way M'Arthur procured a ram and ewe from this royal flock at Windsor, and carried them back to Australia. These, then, with those shipped from the Cape are the ancestors of the great flock in Australia to-day that supply us with millions of pounds of wool."

FLOCKS OF ARGENTINE

In the wool-room at the plant, besides Australian fleeces there are fleeces from Canada, England, Scotland, South Africa, South America, and the United States.

"This burr," we are told, "that resembles a groundhog with long horns, came from one of the Argentine fleeces where one hundred million sheep graze and where if this number were divided equally every one in that republic would own one hundred sheep. There was grass also clinging to the wool. Other fleeces were from the Falkland Islands, where on nearly two million and a half acres of pasturage graze seven hundred and fifty thousand of the finest sheep in the world."

Vegetation, we learn, in the Falklands is very luxuriant, but there are no trees. The winds there do not permit them to grow. It is said that the king of the Falklands has one aim in life and that is to raise a tree. The pasturage, however, is excellent for sheep-raising.

Literally, then, the world contributes to the wool-room at the Kenwood Mills. After being sorted on tables by workmen equipped with

WOOL-ASSORTING DEPARTMENT

large shears, the wool is graded—sometimes five and six grades to a single fleece—and then blended in order to produce a given texture. It may here be said that every process through which the wool passes up to the production of the finished paper-makers' felts and jackets is a process that combines with its own essentials that of removing dirt and dust. In the wool-room the assorters while going over the fleeces and wool fibres remove dirt, vegetation, and strings. Much of the dust while handling the wool sifts through the screens placed across the work-benches.

VARIOUS PROCESSES

A duster that resembles the funnel of a steamship next receives the wool and by passing it over rolls with spiked teeth prepares it for the very important process known as scouring. Careful judgment and skilful attention are required in this process. And since the water of the Hudson River is too "hard" for wool-washing, it is given the necessary softness that it lacks, by the Permutit System which has been installed in the plant. The object of scouring the wool is to

remove impurities that are in the wool and also to open it up so that it is prepared for the subsequent process of carding.

The swing-rake machine that performs this process resembles a huge tank into which are suspended rakes with teeth of varying lengths that slowly separate the wool and free it from dirt and dust. This swing-rake machine was suggested by the original method of handling this process. At first a man stood at the vat and tossed about with a pitchfork the wool in the vat so that it was thoroughly treated. To the inventor, from watching this, came the idea of attaching the prongs of a swinging rake. From the first tank the wool is passed to a second tank containing a semi-wash, and then is gradually moved forward to a third tank, where the wool is rinsed before the water is squeezed out by rollers. Thence it is conveyed to the wool-drying machine that resembles an iron house, where a series of fans blow hot air through the wool as it passes through the dryer on an endless wire apron. It is then blown by another fan to the various bins in the wool-room on the third floor. From these bins various kinds of wool are selected and blended preparatory to the carding process.

CARDING THE WOOL FOR SPINNING

As we have followed the wool from the great bales piled in the storehouse to the wool-assorting room, through the scouring and drying processes to the wool-storage bins where it awaits transportation to the carding department, let us proceed through the mill. Rousseau once said that "you require much philosophy to observe accurately things that are under your noses," and it is safe to say that this remark is nowhere more applicable than when for the first time a novice watches the operation of a carding-machine. Even so, intricate as it is, the action is the same as that of the hand-cards that in many places were in use within the present century, and have now practically disappeared save perhaps among the Navajo Indians, who in making their rugs still use the hand-cards and practise hand-spinning.

The old-fashioned carding was done by two pieces of wood covered with card-cloth of a thin leather to which were attached fine wire points. The cards were provided with handles, and the process of straightening the wool fibres and equalizing their length was accomplished by drawing these cards over each other until the wool was torn open and blended by the wire teeth. After the wool was thor-

(From a photograph by George R. King)

NAVAJO INDIAN WOMAN WEAVING BLANKET ON NAVAJO INDIAN RESERVATION, JUNE, 1912

oughly combed the cards were rolled over each other in order to make the wool into a roll or what is now known as roving.

This is exactly what a great modern machine does, the whole process as with the hand-cards being one of carding and stripping or hooking and unhooking the wool fibres.

SPACIOUSNESS, LIGHTNESS, AND AIRINESS OF THE KENWOOD CARDING-ROOMS

The carding-rooms at the Kenwood plant are among the finest to be found in the entire mill. The rooms are very light, nearly all of the wall-space being given over to windows. The ceilings and walls are white, and in convenient spaces where the workmen can readily reach them are large steel lockers, each man having one of his own for clothing or anything that he may wish to keep there. The machinery is the latest designed for carding, and most of it was built under special directions for the work that the plant wishes performed. There was a long period of invention and development and perfecting between the original hand-card—the early attempts of a Kay or Paul, a Crompton or an Earl, who either invented or perfected—and these huge Kenwood machines which give one the impression of a bustling woman who, intent upon her task, systematically goes about the conversion of fluffy, newly washed wool into the roving that is wound on spools and made ready for the spinning-rooms. In the beauty of the machines themselves one might almost fancy that a woman's touch was apparent,—in the immaculate condition in which they are kept, their brightness, the exactitude of their movements, and the unerring stroke as they handle the wool fibres. The wool is combed with far greater nicety than it could ever be combed by hand.

INGENUITY OF MACHINE-CARDING

At the back of each machine is an automatic feeder in which the wool is placed by the feed-tender. As the wool is received by the feed-rollers that act very much as a spool does when strands of hair are wound around it, they in turn pass the wool with a rolling motion along to what is known as the first breaker, where the carding actually commences. The action here, as has already been said, is that of a hand-card on a colossal scale. Where the hand-card had card-cloth on which were fastened wire teeth, the modern carding-machine has huge rolls on which are thousands of wire teeth that at one time or another

perform the task of seizing the fibres presented them and tearing the wool apart or straightening it, as the case may be. Here the worker, or top roll, performs the work of the upper hand-card, while the lower roll, or cylinder, takes the place of the bottom card. This process employs not only one set of rolls and cylinders, but several—the main cylinder in every case being the heaviest worker, acting not only as a bottom card for every roll, but performing besides the duties of carrier as the wool is conveyed from one roll to another.

The process through which the carded wool is passed before its final preparation for spinning takes the place of the rolling motion that the hand-carders used when they wished to make the wool into a roving. The roving that is gathered automatically from the cards resembles a fluffy white festoon. This is separated into smaller strands and wound on spools preparatory to its transmission to the spinning department.

DAME GOODMAN'S SURPRISE

If the good housewives of the American colonies might step out of the past and visit these vast carding-rooms at the plant, well might they exclaim over the ease and precision of machines and the men operating them, and over the intermediary process of converting millions of pounds of wool from its natural condition on the sheep's fleece to the finished paper-makers' felts. Probably they would linger longest in the carding-room, for here the advance in machinery has been greatest, and the imitation of human dexterity the most perfectly reproduced.

A GLANCE AT THE PAST OF CARDING

In dwelling on the mechanical part of wool-carding, it is well to remember the story of wool-cards. The father of carding wool by machinery appears to have been Lewis Paul, an Englishman, who in 1748, it is said, was the "patentee of the invention of revolving cylinders for carding cotton." "This machine," continues *A Memoir of Samuel Crompton,* "is the original of the machine for carding now used." Crompton himself more than a quarter of a century later invented a carding-machine that did not prove practical. It remained for Pliny Earl, an employee of Samuel Slater, who introduced the Arkwright machines in America, to perfect cards that were supplied with power by a water-wheel attended by one Samuel Brunius Jenks, a negro belonging to the Slater establishment in Rhode Island. The story is told of Slater's trouble with his water-wheel that in winter

froze every night, and Slater, who could find no one willing to endure the temperature of the water to break the ice, was obliged to rise from two to three hours before breakfast in order to prepare for the day's work.

AMERICAN AND ENGLISH EFFORTS TO PERFECT CARDING

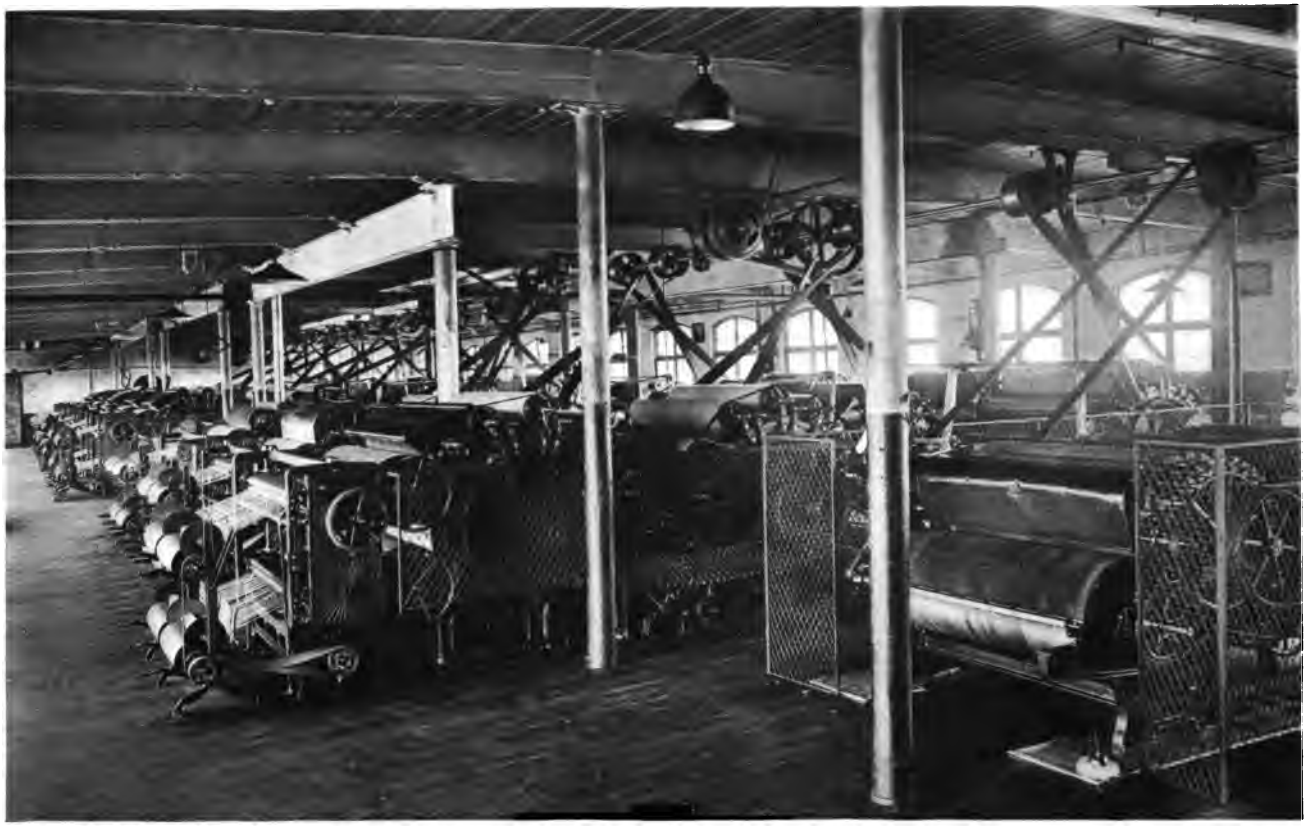
At Philadelphia, which has long been a textile machinery centre, Oliver Evans in 1777 made teeth for cards, and the inventions that he perfected were rapidly taken up by various concerns. In less than twenty years carding-machines were made in considerable numbers, and perfected and enlarged here and abroad. The first practical addition to Daniel Bourn's carding-machine, to which for the first time was applied the rotary motion the same year that Paul patented his invention, was made by John Lees, a Manchester (England) Quaker in 1772. To this the following year James Hargreaves put the finishing touch in a "doffing knife" that was patented by Arkwright, Hargreaves receiving neither credit nor cash for his valuable addition to carding. As late as 1819 hand-carding was still in vogue. Rees, unlike most writers, gives the following description of the origin of the carding process:—

"The preparing of wool for spinning was probably first effected by the fingers and afterwards by the fuller's teazle or thistle, which, with its rough and hooked points, was well adapted to the purpose, and has continued in use to the present day. The card afterwards used was probably a substitute for the teazle." A writer of the present century adds that this original hand-card must have been an exact counterpart of the hand-board covered with teasels which is still (1908) to be seen in wool-raising establishments in the west of England.

The overseer of carding and his assistants must be men of long training and extreme skill. Not only is carding one of the most important of all the wool-manufacturing processes, but mistakes made here can never be corrected and only perfect carding can make perfect felts.

HOW THE MULE SPINS THE ROVING

As one of the properties of paper-makers' felts is to filter water, the hardness and firmness of the twist variations made in spinning become most important. Before reaching the spinning-rooms, wool has been blended to a certain formula and carded to a certain thickness. In



CARDING DEPARTMENT

the spinning-rooms, yarn is spun to a certain standard by a process of drawing, twisting, and winding the yarn on the bobbin by spinning.

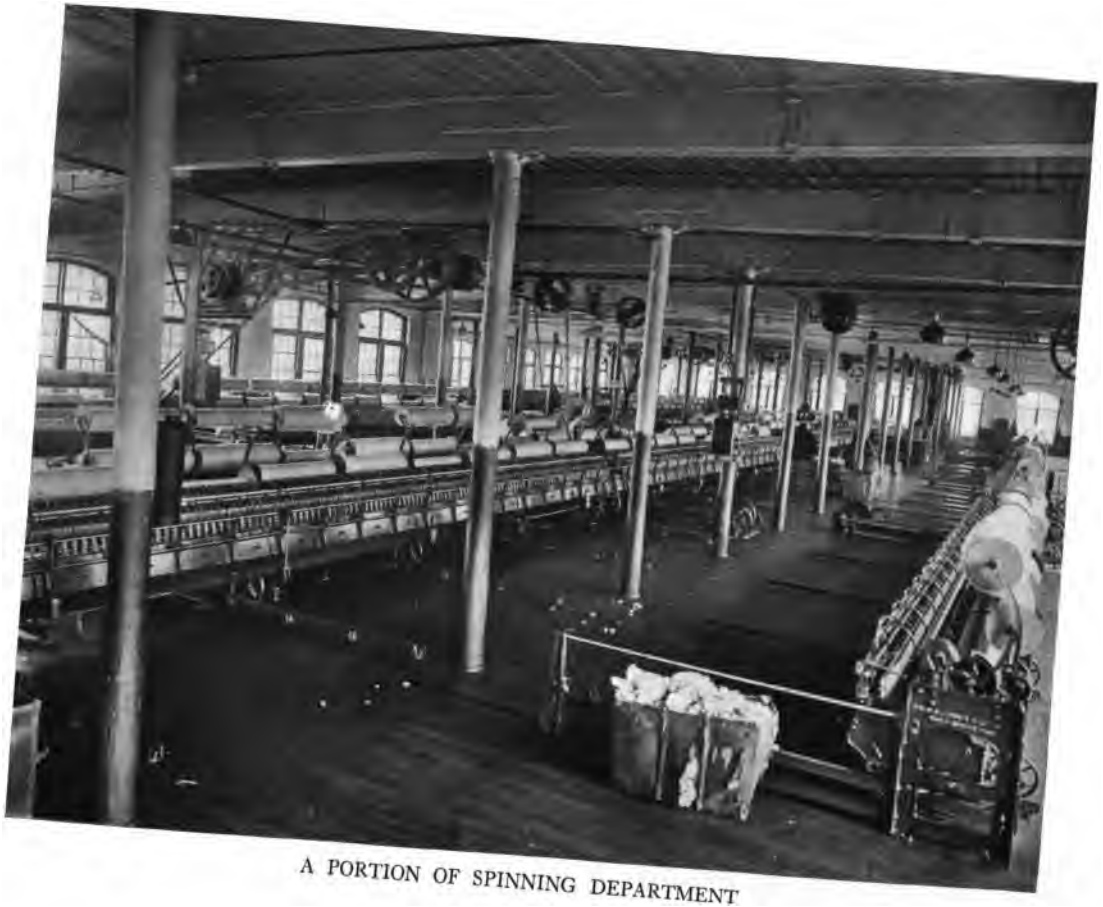
Just as wool occupies the first place in the story of textiles, both in age and importance, so the art of spinning and weaving ranks first among the arts as practised by the ancients. Just as sheep have been known in all countries from remotest times, so the art of spinning and weaving has been found among almost all of the old nations of the world. In Egypt in Joseph's time Pharaoh was arrayed in vestures of fine linen; when Moses built the tabernacle in the wilderness "the women that were wise-hearted did spin with their hands, and brought that which they had spun, both of blue, and of purple, and of scarlet, and of fine linen"; and in Proverbs the virtuous woman is described: "She layeth her hands to the spindle, and her hands hold the distaff."

ANCIENT METHOD OF SPINNING

The Greek mythologists portrayed Minerva and Parcæ holding distaff and spindle, while Solomon held that spinning was the industry of the virtuous woman. The ancient distaff was about three feet long and made of a reed that had an arrangement at the top to hold the ball. The women held the distaff under the left arm while the right hand drew the fibres from the ball and twisted them between the thumb and forefinger of the right hand. The thread thus made was wound upon the spindle—made of a reed from eight to twelve inches high. One of the first lessons that a novice should learn in an effort to understand the processes of the mule is that of hand-spinning, for there he will learn that the mule is very simple in its construction, having exactly two parts: rollers and spindles. The spindles have three motions: they move away from the rollers and extend the roving to a greater number of inches than its original length; in the second place they put a twist into the roving; and in the third, they wind the yarn onto bobbins.

UP-TO-DATE SPINNING

The progress in the spinning-rooms at the Kenwood plant is notable, as all of the machinery formerly used has been discarded and the most modern machinery installed. The new machinery is much heavier than that used when the mills were first built. The various spinning-rooms at the plant are on the same floor as the carding-rooms,



A PORTION OF SPINNING DEPARTMENT

thus facilitating the transference of the roving-spools to the spinning department.

HUMAN INGENUITY OF THE MULE

There is an overseer of the spinning-room, whose duties are to direct the work of the machine. A guide says that he must understand the mechanism, operation, and results obtained. He must have had experience as a spinner and some knowledge as to the repairing of mules. Working with him is a mule-fixer, whose duties are to watch the mechanism of the mule spinning-machines and see that they are kept in working order. The guide adds: "The spinner's duties are to operate the woolen mule, which receives the wool on roving spools from the card-room, and deliver it on the bobbins to the weave-room. The routine duties are, setting in the roving at the back; placing in the roving ends; piecing in ends that break down; regulating the winding conditions so that bobbins will be properly filled; doffing bobbins and replacing new bobbins. The mule-spinning assistant is practically an apprentice; he brings the roving from the card-room; assists in the spinning operation; removes the remainder of waste from the roving spools; returns spools to card-room, and assists in doffing and replacing bobbins."

Take a single machine for example. The spinner places the roving-spool at the back of the mule and extends the roving to the bobbins or spindles—a single thread to each. The process that occurs when the mule is set to work at first appears cumbersome and then marvellous. The carriage containing the spindles moves away from the rollers just far enough to stretch the roving to a desired length. When the rollers stop and the carriage has extended as far as it is intended to go, and the proper twist has been given to the roving, the carriage returns to the rollers and the process is again repeated. It is said that if a spinner know something about a spinning-wheel it is of no small value in estimating just what twists to use on the mule, much depending of course on the quality and length of wool fibre. It is claimed by an eminent authority on the subject that there are few pieces of mechanism so complicated as the various wheels, clutches, and pulleys that control the spinning-mule. As an exception to the insight that some are given in its operation, the story is told of the Japanese foreman who, having never operated a mule, walked a two days' journey in order that he might see one running. Arriving at the mill, he

watched the mule, remaining two days, and then went home. Two mules from England were awaiting him in cases, and these he unpacked and set up without assistance. In two short days he had been able to comprehend every motion of the mule, had by careful observation been able to place rollers, wheels, and spindles, and had absolutely grasped the relation of the various levers and pulleys that controlled the headstock.

HARGREAVES AND THE SPINNING-JENNY

Great as has been the advance since spindle and distaff gave way to the spinning-wheel, almost as great was the accomplishment when a poor weaver, James Hargreaves, invented the spinning-jenny. The idea occurred to him when, upon seeing one of his children upset a spinning-wheel, he noticed that the wheel continued to revolve, and he wondered if several spindles were placed together if it would not be possible to spin several threads at once. He worked out his idea and patented his invention in 1770, naming it in all probability for the child who had overturned the wheel. From eight spindles the number was increased to twenty, thirty, and one hundred and twenty. It remained for Samuel Crompton to combine the Hargreaves spinning-jenny with an Arkwright invention that had been used for cotton. But Crompton was poor and no money was forthcoming for the development of his ideas, and it was some time before he gained the attention of the public. Numberless improvements followed, but it has taken more than a century to usher in the modern spinning-machine. And long ago seem the days that the poet praised the spinning-jenny when he sang,—

> "But patient art,
> That on experience works from hour to hour,
> Sagacious, has a spiral engine form'd,
> Which on an hundred spoles, an hundred threads,
> With one huge wheel, by lapse of water, twines,
> Few hands requiring; easy tended work,
> That copiously supplies the greedy loom."

After the yarn is spun at the Kenwood Mills, it is conveyed by carriers from the spinning- to the weaving-rooms. The bobbins are delivered to spoolers—a number of girls who rapidly transfer the yarn from the bobbins to warp spools. Cop-winders also transfer

yarn from bobbins to cops preparatory for the loom. This change is made by machinery that works very much like a bobbin attachment on a sewing-machine, the empty spools being replaced and the filled ones taken out by the girls operating the machines.

WEAVING, FULLING, AND NAPPING

Unlike paper, paper-makers' felts go through innumerable processes before the finished product is obtained. For instance, those familiar with the Fourdrinier machine watch pulp mixed with water fed into one of the machines, and in less than a minute that same moist pulp has been converted into a part of a web of paper that is rapidly wound on a roll often a mile or more long. In making paper-makers' felts, the number and variety of machines that do their part toward producing the finished product is constantly a source of interest to those unfamiliar with the processes of the manufacture. Whereas the Fourdrinier machine used in manufacturing paper is the result of one man's thought plus the improvement devised by many inventors, the

NO. 1 WEAVING DEPARTMENT

LOOM FOR WEAVING ENDLESS FELTS
Weaving space 416 inches in which seamless felts are woven 66 feet long

carding-machines, spinning-mules, looms, fulling-machines, dryers, are the result of individual efforts on the part of innumerable inventors to perfect the art of woolen manufacture.

ANTIQUITY OF WEAVING

Like spinning, evidences of weaving have been found in the earliest times, and it is believed by authorities on the subject that the art dates back not only to the Stone Age, but to the days when prehistoric man inhabited the earth. When history began, the East was making fabric of flax, cotton, silk, and wool. The Bible frequently refers to the art; the Chinese are said to have woven silk as early as 2640 B.C., while the Egyptians by way of signifying that Isis was the goddess of weaving and its inventor placed in her hands a shuttle. From the East the art of weaving spread West, where it was gradually improved, and where in 1785–86 Edmund Cartwright invented the power loom. The improvements on his invention both in England and America followed each other in rapid succession.

At the Kenwood plant the most intricate modern machinery has been installed in the weave-rooms. Here are looms that weave the endless felts, the exclusive use of which F. C. Huyck and Sons secured for the United States. Some years ago when he was in England he wrote one of his sons, "I have heard of a loom that weaves endless felts." The next letter contained this line, "I am starting to-morrow to see the looms I mentioned." And the third letter announced, "I have ordered three of these looms."

Other looms in the weave-rooms produce felts that are afterward joined or made endless by hand. "Time flies like a weaver's shuttle" is a much quoted axiom, and the flight of the weaver's shuttle as exhibited on these looms is a rapid, human motion. Let it be understood first of all that weaving means arranging yarn so as to form a firm piece of cloth. This is done by placing the warp yarn in such a way as to form a close network of threads. The loom itself is a massive frame on which is placed a beam from which the warp yarn passes through the harness and reed to the front of the loom, while the shuttle darts across, weaving in the filling yarn, thus forming the fabric.

Of all the processes through which the Kenwood paper-makers' felts pass, weaving is the most interesting. In some of the weave-rooms are seamless felts woven on immense looms that have a reed space or width of over four hundred inches; in others, felts are being woven to a length of nearly two hundred feet; in fact, there are being woven felts of a width and length to meet the needs of any paper-mill. The one impression that is left on the mind is that great lengths of paper-makers' felts are being swiftly turned out by the looms and that the busy, swiftly flying shuttles apparently do most of the work. An overseer of weaving watches not only the quality of the paper-makers' felts and jackets as they are turned off, but he carefully examines the yarn that has been previously delivered from the spinning-room. The warpers, drawers-in, and weavers are assisted by loom-fixers, who place warps in the looms and prepare them for weaving. The loom-fixers also mend breaks that occur in the looms and remove the empty beams when the last felt is woven. The cloth-measurers measure the felts as they come from the looms, cut them off into required lengths, and transfer them to the burling-room, where any mistake or flaw in weaving is very carefully corrected.

A VIEW OF LOOMS IN NO. 1 WEAVE-ROOM

BURLING AND JOINING

The burling-rooms are very light, and the felts are at first examined by a staff of girls working over tables. Here, if knots occur in the felts, they are untied and imperfections of weaving are corrected. That the inspection may be thorough, the final care is given by girls, working in pairs, who stand between the felts which have been placed over a frame or perch. Facing the light, with the felt between the workers and the light, any defects that are finally discovered are remedied. After this second inspection the felts that have not been woven seamless are passed to the joining-room, where a staff of women perform the dexterous process of joining. The felts are placed end to end across long tables and then drawn together, each opposite thread exactly matching. At the end of each felt is a fringe of warp. The threads of this fringe are tied in a knot and then the joiner pulls the thread farther into the warp on either side until a seamless felt is entirely woven by hand. This is the process that was performed a half-century ago by the women living round about Rensselaerville.

WASHING AND FULLING THE FELTS

In order to remove the oil and dirt that have accumulated during the processes of carding, spinning, and weaving, the felts are taken from the joining-room and washed in tubs, over which they are suspended on rollers that hold them while they are passed through the tubs of water.

Because the felts when they come from the loom must be shrunk to a required exact size and have not been really felted, they must be put through the felting process before they are suited for the use they are to fill in paper-mills. This process is termed "fulling," and the purpose of it is to shrink and thicken the fabric and to prepare it for the nap that must be put on before it can be used to absorb water. As one goes into the large fulling-rooms at the Kenwood plant, in contrast there arises a picture of the old way in which woolen fabrics were prepared for use. Before the advent of the fulling-mill or fulling-machinery the cloth was beaten with sticks, or subjected to an entirely different process if the young men and women of the neighborhood wanted a party. Some one in these early days gave the following account of one of these affairs: "When the cloth of the season was woven, the young people were invited to the house, the kitchen floor was cleared for action, and in the middle were placed stout split bottom chairs in a circle connected by a cord to prevent coil. On these

JOINING-ROOM

The felts that have not been woven seamless are passed to the joining-room, where a staff of women perform the dexterous process of joining

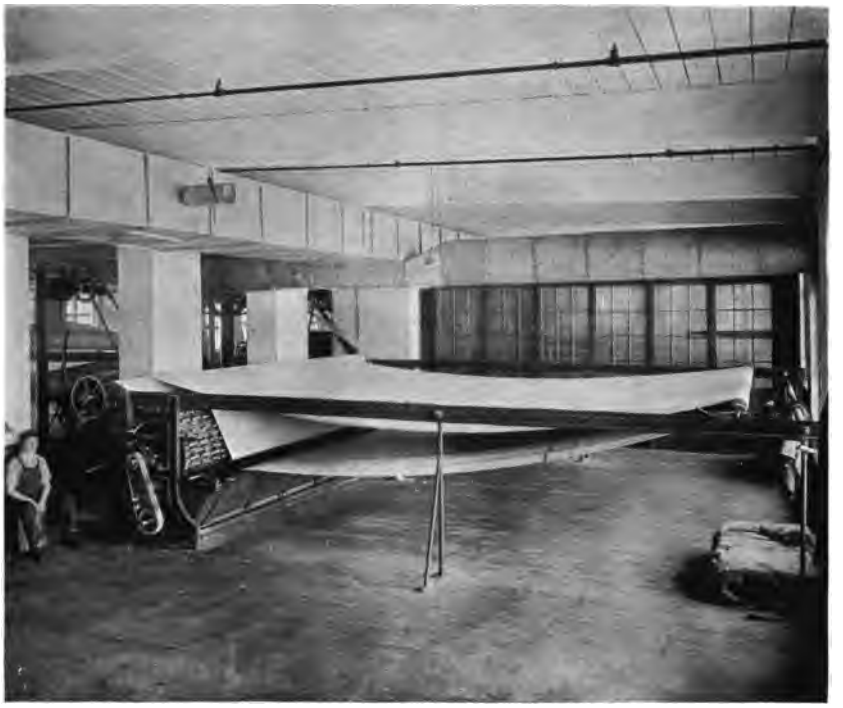
BURLING OR MENDING DEPARTMENT

Here if knots occur in the felts they are untied and imperfections of weaving are corrected

the young men sat with shoes and stockings off and trousers rolled to the knee. In the centre were placed the cloths wetted with warm soap and suds and then kicking commenced by measure steps, driving the bundles of goods round and round the circle, until they were shrunk to the desired size. Then the girls, arms bare to the elbows, rinsed and wrung out the flannels and hung them on the fence to dry." Fulling is a very old operation, and even to-day there is more or less mystery about why and how wool fibres cling together, making a close, compact fabric. As early as 1655 John Pierpont built a fulling-mill in Roxbury, Massachusetts, and others that followed in the same State were one at Watertown in 1662, another at Andover in 1673, one at Ipswich in 1675, and one at Barnstable in 1687.

Fulling or felting, the process from which paper-makers' felts receive their name, is the method of utilizing that peculiar property of the woolen fibre, before mentioned, through which one fibre interlocks with another and in doing so shrinks in length until the full width of the piece of cloth becomes very much less than its woven width. The three agencies through which this process most readily takes place are heat, friction, and moisture; and it is in providing more efficient means of applying these agencies that the development of fulling-machinery has been made from olden times, when the fulling process occurred by the stamping of the piece of cloth with the feet, through the time when fulling-mills consisted of large hammers suspended from a tub and alternately dropped on the fabric, to the time when the modern fulling-mill receives the woolen goods in a long string and by continuous motion passes it while in a moist condition through heavy rollers. The results desired have always been the same; namely, a thickening and strengthening of the fabric, the increasing of its wearing quality, and of its resistance to cold. In paper-makers' felts, the desired object is to gain in strength as much as possible without making the fabric so close that water will not pass readily through it. The overseer of fulling and his assistants must have a knowledge that can only be gained through long experience in the particular fabrics that they are working on.

In the manufacture of paper-makers' felts, when it is necessary to bring a single felt down to the exact size of inches in width and of feet in length, when this size may be, as it has been stated, as long as one hundred and eighty feet or as wide as two hundred and fifty inches, it is easy to realize the skill that must be exercised to bring the proper results. There must be no shrinking after the felt is finished, for on



NAPPING- OR RAISING-MACHINE

the paper-machine it must maintain its width and length throughout its use, nor can there be any stretching, which would be just as detrimental to its service on the paper-machine; at least, both shrinking and stretching must be confined within small and known limits. For these reasons, the importance not only of skill and experience on the part of the workmen but of proper designing of machinery is evident. Most of the fulling-mills in the Kenwood Mills are either manufactured in the plant's own engineering department or made after its own designs. Here you will find a mill small enough to full the smallest-size felt properly and others large enough to receive a single piece weighing from one to two thousand pounds.

PUTTING ON THE NAP

From the fulling-room the felts are taken to the gigging- or napping-room, where on machines having great rollers the felts receive a nap from small spindles covered with teasels. Teasels are the seed-pods

SMALL DRYER

2 feet diameter, 145 inches wide. Weight 1,800 pounds. Drying felt 28 feet long by 51 inches wide

of a plant and have sharp springy points which have never been imitated successfully. These teasels when set revolve on little spindles about the roller against which the felt is passed and in this way the nap is put on, a man having wide experience in napping being in charge of the department. "He must know," says the guide, "the mechanism of the machine; he must know the proper sharpness at which to keep the teasels, and must have an exact knowledge of the finish that is required. He must be able to produce a maximum nap without injury to the fabric."

DRYING

After receiving the nap, the felts are ready for drying. This process is performed by men, working in pairs, who adjust the felts to the dryers—large steam-heated rolls—and who, after stretching the felts on frames and measuring them for a required width and length, remove

LARGE DRYER

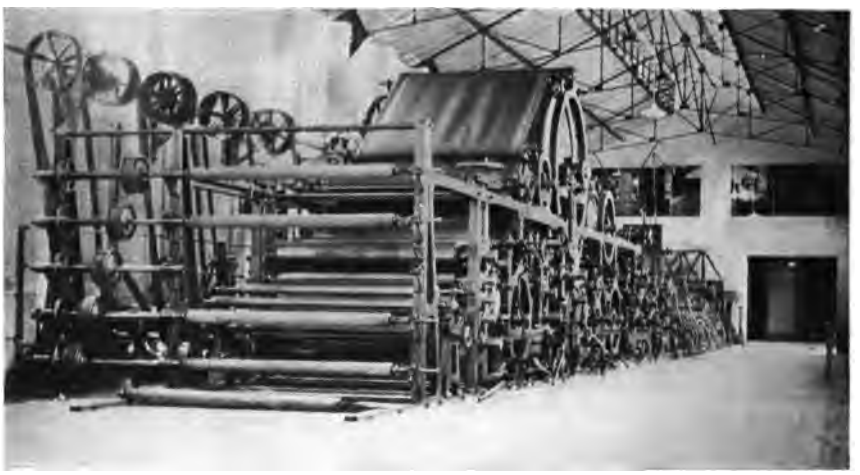
5 feet diameter, 264 inches wide. Weight 18,000 pounds. Drying felt 56 feet long by 212 inches wide

them when completely dry. In this room is a dryer with a cylinder twenty-two feet long, five feet in diameter, weighing nine tons—the largest dryer ever made. After the felts are dry, inspectors, working in pairs, place them on frames facing the light and there take out any foreign matter, either vegetable or wool, that they find. This is the last of the many inspections, and it is attended with the care that all previous inspections have had. The next step is the removal of the felts to the shipping-room.

THE SHIPPING-ROOM

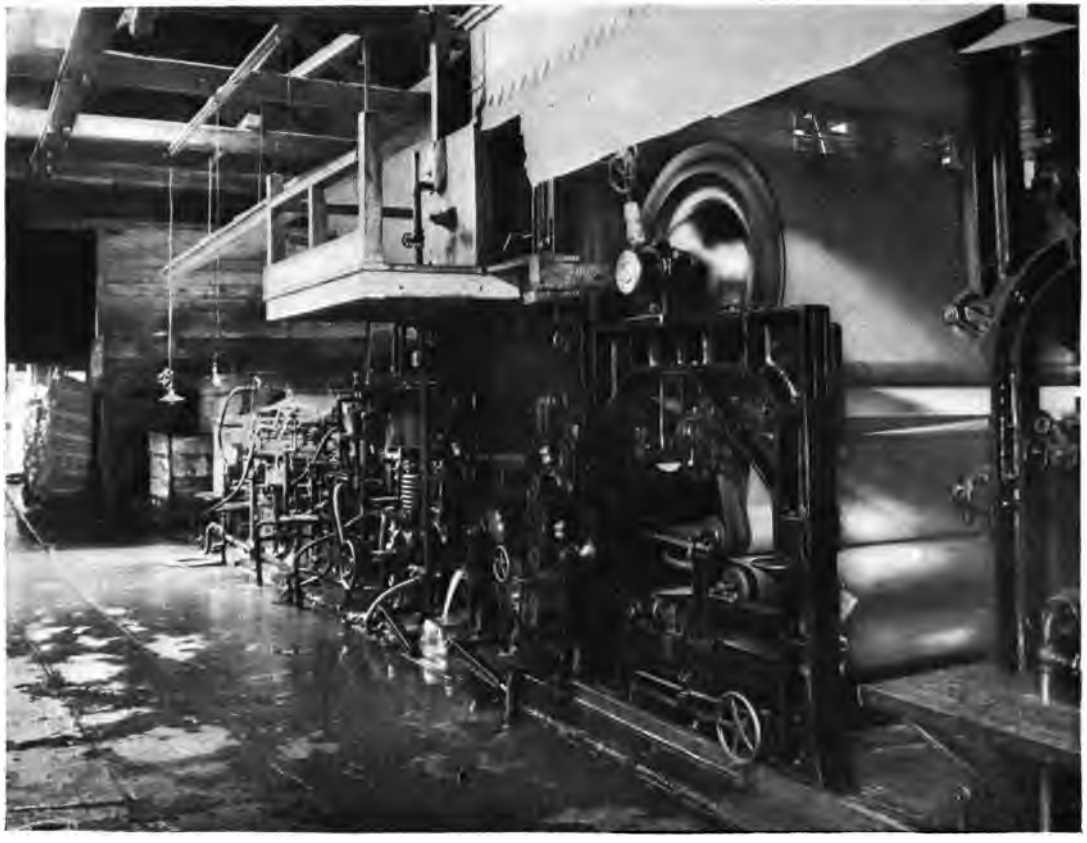
The shipping-room at the Kenwood plant is as cosmopolitan as the wool-room, for in this room are bales and boxes marked with names that represent the entire paper-making world. A notable feature of this room is the neatness and order of arrangement and packing. It is supplied from the packing-room, where, on well-arranged shelves,

PILE OF WOOLEN DRYER FELTS, EACH WEIGHING OVER 1,000 POUNDS



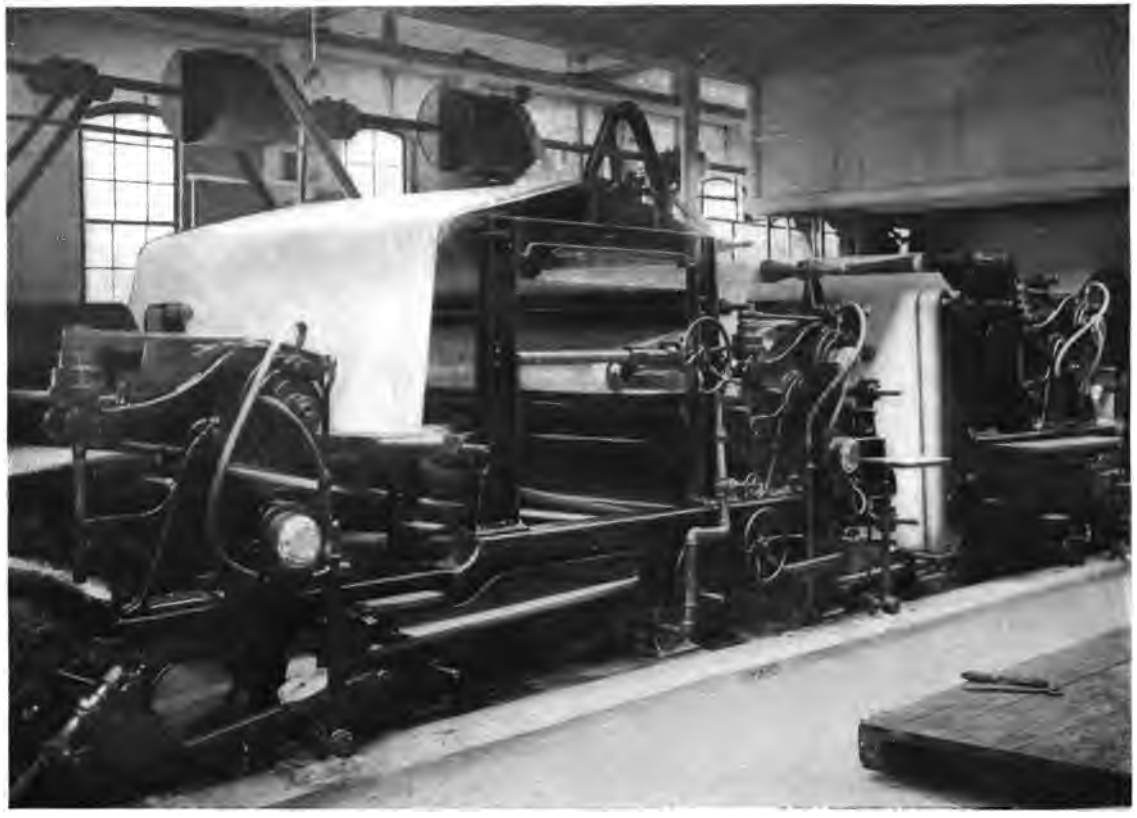
MACHINE ROOM

Fabrica de Papel de Maracay of Venezuela



FIRST PAPER-MACHINE INSTALLED IN JAPAN, 1874, SHOWING PRESSES AND FELTS

This machine is still running



PART OF ONE OF THE LAST MACHINES INSTALLED IN JAPAN, SHOWING FELTS

are thousands of felts ready for consumers that require a certain size. The width ranges from the little forty-inch-wide felts still in use for some purposes to the Fourdrinier felts that already measure two hundred and twenty-four inches and will soon be two hundred and fifty inches wide when machines now being built are completed. Reliability of product, excellent shipping facilities, and efficient foreign agents have placed the felts among the foremost products of their kind. The situation of the plant is advantageous; having its own sidetracks, and the fact of its nearness to the Hudson River where steamers run daily to New York, has aided foreign shipments. The felts may be shipped on these steamers at night and the following morning transferred to an ocean liner, or they can be sent forward to any Pacific port and thence shipped to Japan, China, or Australia. Japan erected the first paper-machine in 1874, and since then the industry has grown enormously, and shipments of Kenwood felts to that country have increased correspondingly. In every paper-making State of the United States—from New England, through the Central States, to the Pacific Coast, where the paper-making industry has made marked progress—the Kenwood felts are used. In the South, where recently the paper-making industry has progressed rapidly owing to the use of long-leaved pine for pulp, shipments are constantly increasing. Among the largest consumers of the felts are Australia, Argentine, England, Finland, Holland, Japan, Norway, and Sweden.

ENGINEERING DEPARTMENT

One usually thinks of an engineering department of a plant as solely concerned with supplying power, heat, and light and making repairs to machinery. This is not the case in the engineering department of the Kenwood Mills. Many special machines are designed and built here, many inventions perfected, and much that plays a vital part in the efficient development of the plant has its origin in this department, where skilled mechanics and draftsmen work under the instruction of an able supervising engineer.

ACCOUNTING DEPARTMENT

The same thing may be said of the accounting department. It is not simply a place where routine work is done. Efficient purchasing methods, a cost-accounting system which is accurate and thorough,

A GROUP PICTURE

The success of the business and the importance it has attained in the industry are the result of the efforts of hundreds of men and women working in harmony and with a spirit of co-operation

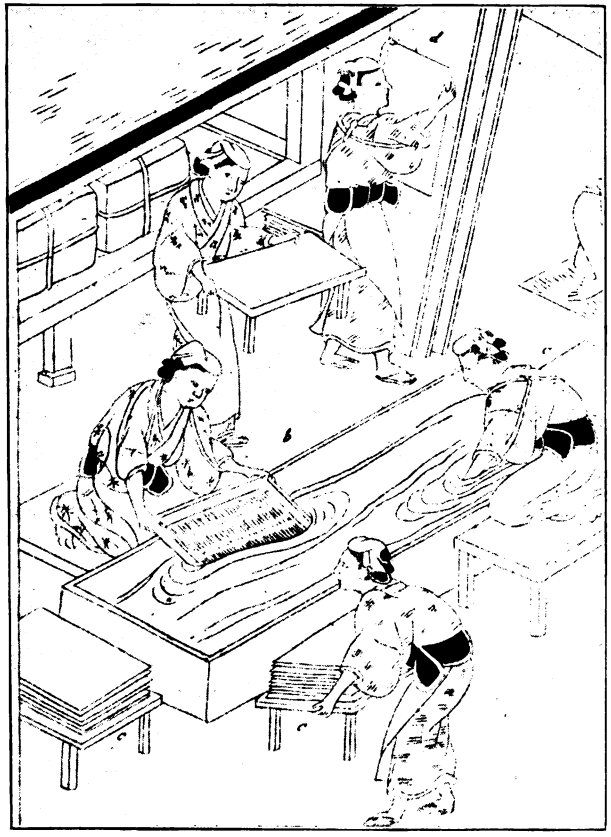
and the latest methods of general accounting, carefully conducted correspondence, and complete and accurate records help materially in giving efficient service to the users of Kenwood felts.

The Kenwood Plant having drawn its raw materials from the whole world, returns to the world its finished product. New conditions are constantly arising and being met.

Probably it will be some years before the wood pulp of the United States and Canada is exhausted. Experiments, however, are already being made all over the world in order to provide substitutes for wood pulp. Most particularly in the United States and her possessions attention is being turned to the South, Hawaii, and Porto Rico, which are expected to be the producers of the world's supply of pulp in future years. The waste materials of sugar-cane—called in Cuba and Porto Rico, megasse, and in Hawaii, begasse—are being experimented on, also bamboo, as a raw material for paper pulp. A mill in Hawaii erected a year ago has made considerable progress in utilizing begasse and in manufacturing a row mulching which is somewhat similar to a roofing and is used to increase the growth of sugar-cane and prevent growth of weeds. This waste, heretofore being exceedingly cheap, has been used by the sugar-cane mills for fuel. Sugar-cane requires a great deal of fertilizer, and the fact that the row mulching can be manufactured from waste, cut into thirty-six-inch rolls and carried on donkeys to the fields, where it is easily unrolled and spread on the sugar-cane sprouts which penetrate the paper, is of especial advantage to the producer, especially as the row mulching destroys the weeds, which cannot penetrate it. This paper also prevents the fertilizer in the ground from being washed away during the heavy rainfall. By the use of this, all cultivation is done away. Measurements have shown that the height of the sugar-cane in a given time greatly exceeds the height of the stalks grown where the paper has not been used, and the yield of the sugar-cane has been increased.

THE SOUTHERN STATES OF THE UNITED STATES A SOURCE OF SUPPLY.

Another source of the supply for wood pulp will probably be the South where long-leaf pine grows in such quantities. It has been shown that for every million feet of lumber cut, there are two million feet of waste. From this waste, after turpentine and resin have been



JAPANESE PAPER FACTORY